PSEG Nuclear LLC
P O Box 236, Hancocks Bndge, New Jersey 08038-0236

OCT 0 2 2002

PSEG
Nuclear LLC

LRN-02-0331
LCR S02-03

United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Gentlemen:

**ADDITIONAL INFORMATION – SPENT FUEL POOL COOLING
REQUEST FOR LICENSE AMENDMENT
REFUELING OPERATIONS – FUEL DECAY TIME PRIOR TO COMMENCING CORE ALTERATIONS OR MOVEMENT OF IRRADIATED FUEL
SALEM GENERATING STATION, UNIT NOS. 1 AND 2
FACILITY OPERATING LICENSE NOS. DPR-70 AND DPR-75
DOCKET NOS. 50-272 AND 50-311**

On October 1, 2002, PSEG Nuclear LLC (PSEG) met with Mr. R. Fretz and Mr. S. Jones of the Nuclear Regulatory Commission (NRC) staff, to discuss the subject request for license amendment submitted by PSEG on June 28, 2002 (LR-N02-0231).

The purpose of the meeting was to discuss information in the submittal related to Spent Fuel Pool (SFP) temperature limits and the calculations performed to determine maximum SFP temperatures. Attachment 1 summarizes our resolution of the issues as discussed at the meeting, and includes regulatory commitments to be met as part of implementation of the proposed amendment. Attachment 2 provides the non-proprietary portion of the Critical Software Document for the Crosstie computer code used for the Decay Heat Management Program calculations. Attachment 3 contains the proprietary portion of the Critical Software Document for Crosstie, and the affidavit to support its withholding from public disclosure pursuant to 10 CFR 2.790. Attachment 4 provides Calculation S-C-SF-MEE-1679 Revision 0, "SFP Cooling System Capability With Core Offload Starting 100 Hours After Shutdown," that is described in our amendment request dated June 28, 2002.

The information provided herein provides additional details regarding spent fuel cooling calculation methodology and operational controls, and it does not affect our determination of no significant hazards consideration contained in our June 28, 2002 amendment request.

This letter forwards proprietary information in accordance with 10CFR 2.790. The balance of this letter may be considered non-proprietary upon removal of Attachment 3.

A001

Should you have any questions regarding this transmittal, please contact Mr. William McTigue at (856) 339-1033.

Sincerely,

D.F. Garchow

D. F. Garchow
Vice President - Operations

Attachments (4)

C Mr. H. J. Miller, Administrator - Region I
U. S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

U. S. Nuclear Regulatory Commission
Attn: Mr. R. Fretz
Licensing Project Manager - Salem
Mail Stop 08B2
Washington, D.C. 20555-0001

USNRC Senior Resident Inspector - Salem (X24)

Mr. K. Tosch, Manager IV
Bureau of Nuclear Engineering
P.O. Box 415
Trenton, NJ 08625

This letter forwards proprietary information in accordance with 10CFR 2.790. The balance of this letter may be considered non-proprietary upon removal of Attachment 3.

1. Decay Heat Management Program Calculations

The Decay Heat Management (DHM) program calculates peak SFP temperature for each refueling outage using the Crosstie computer program. The Critical Software Document for Crosstie is provided in Attachments 2 (non-proprietary) and 3 (proprietary). The results of the DHM program calculations performed for the twelfth refueling outage at Salem Unit 2 (2R12) showed substantial conservatism when predicted SFP temperatures were compared to actual SFP temperatures during the outage. During the October 1, 2002 meeting, actual recorded values of Component Cooling Water (CCW) supply temperatures were used as input to the DHM calculation for 2R12, resulting in calculated SFP temperatures that closely correlated with actual SFP temperatures; this provided validation of the ability of the DHM calculations to predict maximum SFP temperatures accurately.

As part of implementation of the requested amendment, PSEG commits to using the DHM program calculation methodology prior to each Salem refueling to:

1. Calculate that the SFP temperature will not exceed 149 degrees F following full core offload, using one and only one heat exchanger for each SFP and to provide to the Operations staff the required Component Cooling Water temperature to achieve such results.

2. Calculate that the SFP temperature will not exceed 180 degrees F following full core offload with one heat exchanger available for both SFP's and to provide to the Operations staff the required Component Cooling Water temperature to achieve such results.

2. Decay Heat Management Procedures

The integrated operating procedures for movement of spent fuel, S1(2).OP-IO.ZZ-0010(Q), Spent Fuel Pool Manipulations, establish SFP cooling requirements using the Outage Risk Assessment Model (ORAM) logic and Outage Risk Assessment procedure NC.OM-AP.ZZ-0001(Q). These documents establish the administrative controls needed to validate the assumptions used in the DHM calculations.

As part of implementation of the requested amendment, prior to initiating core offload, PSEG commits to

1. Ensuring the availability of both SFP heat exchangers, each with an available spent fuel pit pump, to support spent fuel cooling for a full core offload; and

2. Verifying that actual CCW supply temperatures validate the DHM calculation input requirements.

3. Spent Fuel Pool (SFP) High Temperature Alarm vs. Predicted Peak Temperature

The Salem Unit 1 and 2 SFP high temperature alarm setpoint is 125 degrees F. The alarm setpoint is also an entry condition for abnormal operating procedure S1(2).OP-AB.SF-0001(Q), Loss of Spent Fuel Pool Cooling. Actions directed by this procedure include suspension of fuel movement into the SFP, periodic monitoring of SFP temperature, restoration or increase of SFP cooling, verification of SFP level, and operation of the Fuel Handling Building Ventilation System.

If peak SFP temperature, as predicted by the DHM program, exceeds 125 degrees F for a refueling outage, then exceeding the alarm setpoint is an expected condition, and the alarm would not be indicative of an actual loss or degradation of SFP cooling. Therefore, PSEG commits to maintain SFP high temperature alarm capability to alert the operators in the event that SFP temperature exceeds the peak temperature predicted by the DHM program for each refueling outage. This commitment will be met as part of implementation of the requested amendment.

LRN-02-0331
Attachment 2

Critical Software Document for CROSSTIE

Non-Proprietary

CRITICAL SOFTWARE DOCUMENT

FOR

CROSSTIE

1	Added Note 1 to Section 3.0 to address PIRS item 960125282, CRCA 2, regarding interface with FHB Ventilation System. Added Note 2 to Section 3.0 to address PIRS item 980701273, CRCA 1, regarding spent fuel storage rack and assembly volume. Revised Controlled Copy Holders and CPU information on Attachment1. Revised Index Form (misc. information).	K. King 12/11/98 K. King	R. Down 12/18/98 R. Down 12/18/98	R. DeNight 12/18/98 [illegible]
0	First issue.	K. King 12/9/95	L. Ford 12/9/95	H. Berrick 12/9/95
Revision	**Revision Summary**	**Prepared by Date**	**Reviewed by Date**	**Approved by Date**

TABLE OF CONTENTS

SECTION	DESCRIPTION	PAGE
	Computer Software Critical Parameters	3
1.0	PURPOSE	4
2.0	SCOPE	4
3.0	SOFTWARE DESCRIPTION	4
4.0	REFERENCES	5
5.0	SOFTWARE CONTROLLED DISTRIBUTION	5
6.0	VALIDATION AND VERIFICATION	6
7.0	TRAINING REQUIREMENTS	7
8.0	USERS MANUAL	7
9.0	SOURCE CODE STORAGE	7
10.0	ERROR REPORTING	7
11.0	INPUT DATA VALIDATION	8
12.0	ATTACHMENTS	9
13.0	APPENDICES	9

Computer Software Index Form

Software I.D. No:	*S-C-SF-MCS-0113, Sheet 2*
Software Document Name:	*CROSSTIE*
Software Document Revision:	*1*
System Code:	*SF*
Software Source: (If not PSE&G)	*HOLTEC*

Description of Software Application & Intended Use:

> *CROSSTIE will be used to predict Spent Fuel Pool temperatures when either the Unit 1 or Unit 2 Spent Fuel Heat Exchanger is out of service, with the operational Heat Exchanger being cycled between the two pools, requiring operation of the Spent Fuel cross-tie. This program will also be used to evaluate Spent Fuel Pool heat-up rates and equilibrium temperatures without forced cooling.*

Development/Revision:	*CROSSTIE Version 1.0*
Name of Sponsor:	*K. C. King, EDME/SE*
Software User Designated Contact:	*K. C. King*

Hardware System and Operating System/Software on which Software is run:

1. Current Software Name/Rev.:	*CROSSTIE Version 1.0*
2. Valid Software Users Manual I.D./Rev.:	*S-C-SF-MCS-0113, Sheet 3, Rev 0*
3. Valid Software Theoretical Manual I.D./Rev.:	*N/A*
4. Operating System I.D./Rev.:	*MS-DOS*
5. Hardware:	*IBM PC Model 286, or compatible, with Math Coprocessor* *Windows 95/NT Compatible*

Computer Programming Facilities Used:	*Holtec*
Computer Programming Language:	*Fortran*
Time of Day Program is Normally Run:	*No Restrictions*
Associated Vendor Manuals:	*None*
Other Information:	*Not Y2K compatible – upgrade required prior to 1/1/2000*

1.0 PURPOSE

The purpose of this procedure is to document all pertinent aspects of the installation, usage, and maintenance of the CROSSTIE software application in accordance with references 4.1, 4.2, and 4.3 .

2.0 SCOPE

This procedure is applicable to the usage of the CROSSTIE program for non-safety related, as well as for, safety related applications at the PSE&G Nuclear Department by PSE&G and Contractors performing work for the PSE&G Nuclear Department.

3.0 SOFTWARE DESCRIPTION

The CROSSTIE program is a comprehensive software package for predicting Spent Fuel Pool temperatures, for use on personal computers. It was developed by HOLTEC in support of the Spent Fuel Pool Rerack Project.

The program will be able to predict Spent Fuel Pool temperatures when either the Unit 1 or Unit 2 Spent Fuel Heat Exchanger is out of service. During this time, the operational Heat Exchanger is being cycled between the two pools, meaning at any given time, one pool is being cooled and the other is heating up. Cooling for the other Unit's pool is provided by means of the Spent Fuel cross-tie. This program can be used to predict the rate of rise in temperature for the isolated pool and at what point it will reach the maximum limit, at which point cooling will be swapped to this pool or restored to both pools.

This program will be used primarily as a pre-outage planning tool to determine if a Spent Fuel Heat Exchanger can be taken out of service after the core is unloaded, and if cycling between pools is feasible, amongst other considerations. It can also be used (1) any time taking a Spent Fuel Heat Exchanger out of service is being considered; (2) when a loss of SF cooling is being analyzed; and (3) as a design tool to determine if the Spent Fuel Cooling System will need to be upgraded in the future.

CROSSTIE is a custom software product which may be executed on any personal computer with a standard monitor and hard/floppy drive. Although a printer is not required, a printer is recommended to provide verifiable output.

NOTES:

(1) The CROSSTIE program does not interface with the Fuel Handling Building Ventilation System (FHBVS), and implicitly assumes that the system can maintain the input ambient conditions. Thus, when evaluating a loss of forced cooling scenario, a separate evaluation should be performed to determine if the FHBVS can support the heat removal and pool equilibrium temperature predicted by the CROSSTIE code, and to determine the FHBVS requirements. Refer to User's Guide for further information.

(2) The Spent Fuel Pool net water volume, which is a program input, is the total volume below a given elevation less the volume of the racks and fuel assemblies. The program validation (Appx. 2) was based on testing that was performed prior to the Spent Fuel Pool Rerack. Thus, the current rack volume is different then that determined in Appx. 2, Section 5.1. The number of fuel assemblies, of course, has also changed.

Prior to the rerack, the Spent Fuel Pool contained twelve Exxon racks. Since the rerack, the Spent Fuel Pool contains three of the original Exxon racks and nine new maximum density Holtec racks. The current rack volume, which should be used for future calculations, is as follows:

Exxon Racks:

Inputs
- 300 cells (Ref. 4.4)
- 338 lbs/cell (Appx. 2, Section 5.1)
- $\rho = 0.29$ lbs/in^3 (Appx. 2, Section 5.1)

Volume = (300 * 338)/0.29 = 349655 in^3 = 202.3 ft^3

Holtec Racks:

Inputs
- 1332 cells (Ref. 4.4)
- 136 lbs/cell (Ref. 4.5, page 21)
- $\rho = 0.29$ lbs/in^3 (Ref. 4.5, page 22)

Volume = (1332 * 136)/0.29 = 624662 in^3 = 361.5 ft^3

Total Rack Volume = 202.3 + 361.5 = 563.8 ft^3 say 564 ft^3

The volume of the fuel assemblies is determined based on the process provided in Appx. 2, Section 5.1. The volume of one fuel assembly is:

Volume = 1700 lb / 0.23 lbs/in^3 = 7391.3 in^3 = 4.277 ft^3

Thus the total volume of all assemblies = # assemblies * 4.277

The net water volume in the Spent Fuel Pool, then, should be based on the above rack volume and assembly volume.

4.0 REFERENCES

4.1 NMEDED-0001, Rev. 0, "NME Computer Software Division Procedure"

4.2 ND.DE-AP.ZZ-0052(Q), Rev. 1, "Software Control"

4.3 NC.NA-AP.ZZ-0064(Q), Rev. 1, "Software Quality Assurance"

4.4 DCPs 1EC-3252 and 2EC-3254, Spent Fuel Pool Rerack

4.5 Design Calculation S-C-SF-MDC-1240, Rev. 0, "Spent Fuel Pool thermal-Hydraulic Calculation

5.0 SOFTWARE CONTROLLED DISTRIBUTION

This software shall be used only on authorized machines (platforms.) Each controlled copy holder must verify the installed software prior to initial usage, as well as, whenever the operating system, and/or the computer hardware is changed. Additionally, the verification shall be performed when the CROSSTIE software is updated.

Controlled copies of the executable code shall be installed and verified only on platforms identified on the controlled copy holder list. This list is provided as Attachment 1 to this procedure.

Notification of executable source code revision will be distributed through CCG along with floppy disks containing the executable source code revision, and with instructions for installation, updating, and validation.

Attachment 3 is a sample of NME - Critical Software Revision/Update Notice and instructions. A formal record of executable code update transmittal will be included in

6.0 VALIDATION AND VERIFICATION

The initial verification of this program was performed by Holtec, the developer of CROSSTIE. The Verification and Validation Documentation (Holtec document ID HI-931099) has been reviewed and accepted by PSE&G, and is included in Appendix 2.

Platform validation / verification will also be performed when the executable code is initially installed on a particular PC platform, as well as, when the operating system or hardware of that platform is changed. The results of the initial and subsequent platform verification / validations will be documented on the Validation / Verification Results form provided as Attachment 2 to this procedure. Completed platform validations which are as a result of executable code revision will be filed in Appendix 3 of this procedure. Completed platform validations which are as a result of when the operating system or hardware of that platform is changed will be filed in Appendix 3 of the Software Sponsors copy of this procedure.

The controlled copy holder shall be responsible for the initial software and all subsequent software revision installations, as well as, for all associated platform validations. The controlled copy holder shall forward the completed verification / validation form to the program sponsor when the installation is complete and when the platform revision is complete. The controlled copy holder shall have the verification inputs and results verified by and independent party prior to transmittal to the program sponsor. Specific instructions, if required, for performing the validation will be provided with the installation package.

7.0 TRAINING REQUIREMENTS

No specific training is required to use this application. The users manual contains all the necessary information. The program requires input of test data, including temperatures and flow rates, from the user and does not require any detailed interpretation of the output results by the user.

8.0 USERS MANUAL

Users manuals for this application will be issued through the CCG as S-C-SF-MCS-0113, Sheet 3, "CROSSTIE Software Manual". This manual has a limited controlled distribution. The HOLTEC published "USERS MANUAL FOR COMPUTER PROGRAM CROSSTIE" will be included in the S-C-SF-MCS-0113, sheet 3, "CROSSTIE Software Manual".

9.0 SOURCE CODE STORAGE

CCG has been designated as controlled copy holder number 001 for this software application. CCG will provide storage of this controlled copy in accordance with reference 4.2

10.0 ERROR REPORTING

Error reporting will be in accordance with reference 4.1. Error Evaluations will be documented per reference 4.1, Attachment 1, form NMEDED-001-A1-2. Completed error evaluations will be documented within Appendix 1 of this procedure. A log of error notices will be maintained by the software sponsor. The error log will be documented per reference 4.1, Attachment 1, form NMEDED-001-A1-1. The software sponsor shall update this procedure bi-annually (minimum frequency) to add the current error log to Appendix 1. Additionally, the software sponsor will distribute all valid error notices to the controlled copy holders for inclusion into their "USERS MANUAL FOR COMPUTER PROGRAM CROSSTIE". Error notices will be removed from the Users Manual by the controlled copy holder only after the error has been corrected with a new source code release/revision as directed by the software sponsor.

11.0 INPUT DATA VALIDATION

In accordance with reference 4.1, input data for this software application has been designated as "Uncontrolled Data". As such, the input data for this application will be required to be printed along with the calculation results. The input data will be verified along with the results by the verifier of the design calculation utilizing the results.

12.0 ATTACHMENTS

1. CONTROLLED COPY HOLDER LIST
2. VERIFICATION RESULTS FORM
3. SAMPLE - Critical Software Revision/Update Notice

13.0 APPENDICES

1. ERROR REPORTS AND NOTICE LOG
2. INITIAL BENCHMARK VERIFICATION
3. VERIFICATION / VALIDATION RESULTS

ATTACHMENT 1

CONTROLLED COPY HOLDERS - SOFTWARE

CONTROLLED COPY NUMBER	NAME (Group)	LOCATION	CPU
001	MASTER (CCG)	CCG	N/A
002	Software Sponsor Kevin King (EDME/SE)	NDAB MC N24	Model – Dell OptiPlex GXa Dell S/N – EDP4S
003	Robert Down (EDME/SE)	NDAB MC N24	Model – Dell OptiPlex GXa Dell S/N – E8KT2
004	Emin Ortalan (EDME/NSS)	NDAB MC N24	Model – Dell OptiPlex GXa Dell S/N – G75N2
005	Glen Schwartz (EFU/SA)	NDAB MC N20	Model – Dell OptiPlex GXa Dell S/N – EFXY6
006	Ed Capper (ESSA/SRE)	Salem Tech. MC S02	Model – Dell OptiPlex GXa Dell S/N – EF5HD
007	Unassigned		Model – Dell S/N –
008			
009			
010			
011			
012			
013			

Validation and Verification Results Form

Transmittal Date : 12/09/95

Software Name & Copy Number : «ccn»

Copy Holder Name & Company : «name»

Installation Location: «location»

Installation Computer: «cpu»

Validation and Verification Results:

[ ] ***Success***, the results of the test run match the sample output. Results attached.

[ ] ***Failure***, the results of the test run do not match the sample output. Results attached.

Installer : ____________________ Date: ___________

Verifier : ____________________ Date: ___________

This section to be completed by Software Sponsor. A copy of the completed form will be returned to each copy holder for retention.

[ ] Installation and verification accepted.

Sponsor : ____________________ Date: ___________

ATTACHMENT 2

I. <u>Software Validation:</u>

SOFTWARE VALIDATION SHALL BE PERFORMED WHENEVER THE EPG APPENDIX C PROGRAM IS INSTALLED, WHENEVER THE EPG APPENDIX C SOFTWARE IS REVISED, AND WHENEVER THE COMPUTER OPERATING SYSTEM OR COMPUTER CONFIGURATION IS REVISED OR CHANGED.

NOTES: (1) Read file "DATAFILE.TXT" -- also included as sheet 5A -- regarding data files included with the CROSSTIE program.

(2) These instructions assume the crosstie program is on the "c:" drive under the directory "crosstie". If the program is on a different drive and/or directory, substitute the actual path where it states "c:\crosstie".

Step 1: From DOS Editior, create a data file "case3.dat" as follows:

```
Program CROSSTIE Verification Case 3
10, 02, 93
1
2100, 2040, 60000
0, 0, 0, 240.0, 60.0
3411.0, 1.0, 0.0, 0.0, 0.0, 461.0
75.5, 0.60
```

Step 2: Save file "case3.dat" under directory "crosstie"

Step 3. Run the CROSSTIE Program:
Open file: "c:\crosstie\crosstie.exe"

Step 4. Screen will ask "INPUT THE NAME OF YOUR INPUT DATA FILE"
Type: case3.dat
Press: ↵Enter Key

Step 5: Screen will ask "INPUT TIME AFTER SHUTDOWN TO START CROSS-TIE"
Type: 496.0
Press: ↵Enter Key

Step 6: Screen will ask "INPUT POOL WATER TEMPERATURE LIMIT FOR SWITCH"
Type: 140.3
Press: ↵Enter Key

Step 7: Screen will ask "INPUT CCW COOLANT TEMPERATURE"
Type: 77.0
Press: ↵Enter Key

Step 8: Screen will ask "INPUT ENDING TIME FOR INTEGRATION"
Type: 600.0
Press: ↵Enter Key

CALCULATION IS COMPLETED

Step 9: Create Sub-directory under Directory "crosstie" entitled "verif"

Step 10: Move the following files from the Directory "crosstie" to the Sub-directory "verif":

"case3.dat"
"result.tem"
"plot.dat"

Step 11: Review results from DOS Editior:

Open File "c:\crosstie\verif\result.tem"
Print File
Open File "c:\crosstie\verif\plot.dat"
Print File

ATTACHMENT 2

Step 12: Compare the printed results for "result.tem" and "plot.dat" to the sample output -- page 6 for "result.tem" and pages 7 to 23 for "plot.dat". If results are an exact match (time and date may vary) then installation and configuration validation was a success. Sign and date the appropriate line on the bottom of the cover form, then return the form, and printed output to the sponsor stated above.

II. <u>If results vary in any manner other than date and time then the installation failed.</u>

Step 1 Sign and date the appropriate line on the bottom of the form.

Step 2 Move all "save" and "output print" files to a separate directory to avoid losing them.

Step 3 Delete all of the remaining program and data files from the hard drive of the installation computer.

Step 4 Return the form, and printed output to the sponsor stated above.

III. <u>Hardware Configuration Validation:</u>

Step 1. At the C: Prompt:

Type:	MSD	
Press:	↵ **Enter key**	
Press:	Alt-F	(for File Menu)
Press:	P	(for Print)

Step 2. Using the Tab key to move and the space key to toggle the options select the options as shown below.

Press:	↵ **Enter key**	(for OK)

ATTACHMENT 2

```
+-------------------------------------------------------------+
| Report Information                                           |
|   [ ] Report All *         [X] Mouse          [ ] Memory Browser |
|   [X] Customer Information [X] Other Adapters [X] CONFIG.SYS     |
|   [X] System Summary       [ ] Disk Drives    [X] AUTOEXEC.BAT   |
|   [X] Computer             [ ] LPT Ports      [ ] WIN.INI        |
|   [ ] Memory               [ ] COM Ports      [ ] SYSTEM.INI     |
|   [ ] Video                [ ] IRQ Status                        |
|   [ ] Network              [ ] TSR Programs                      |
|   [X] OS Version           [ ] Device Drivers                    |
|                                                                  |
| Print to:                                                        |
|   (█) LPT1  ( ) COM1 !  ( ) COM4                                 |
|   ( ) LPT2  ( ) COM2 @  ( ) File: [REPORT.MSD.....................] |
|   ( ) LPT3  ( ) COM3                                             |
|                                                                  |
|                      ___OK___  Cancel__                          |
+-------------------------------------------------------------+
```

Step 3. Customer Information screen appears. Use the Tab key to move from field to field.

* Enter your name in the Name field.
* Enter your group in the Company Name field.
* Enter your work location including mail code in the Address1 field.
* Enter your Phone extension in the Phone field
* Enter your computers Brass tag number in the Comments field.

Press: ↵ **Enter key** (for OK)

Step 4. Make two (2) copies of the resulting report from step 3. Provide one (1) with the Validation and Verification Results Form to the software sponsor and maintain the second copy in your CROSSTIE Users Manual for reference when the next Validation/Verification is required.

The data files included with the CROSSTIE computer program -- "unit1.dcy", "unit2.dcy" and "1r11.dat" -- represent the spent fuel burnup data at the time the program was supplied by Holtec, as follows:

"unit1.dcy": U1 SF Pool inventory prior to 1R11 (cycles 1 -> 10)
"unit2.dcy": U2 SF Pool inventory at time of 1R11 (cycles 1 -> 7)
"1r11.dat" : 1R11 specific data

The verification performed by Holtec (see CSD A-0-MCS-0113, Sheet 1, Appx. 1) used these specific data files. As such, the verification to be performed by each Controlled Copy holder (see CSD A-0-MCS-0113, Sheet 1, Att. 2) is to also use these specific data files.

Upon successful completion of the verification, "unit1.dcy" and "unit2.dcy" should be updated to reflect the current SF Pool inventory for each unit.

NOTES:

(1) The CROSSTIE program specifically looks for the file names "unit1.dcy" and "unit2.dcy". If it is desired to maintain separate "*.dcy" files representing the updates from each cycle, they can be renamed for storage purposes. If it is desired to use these files at a future time, they must be changed back these specific file names prior to running the program. As an alternative, they can be stored under individual sub-directories, keeping the same file names.

(2) All data files -- "unit1.dcy", "unit2.dcy" and the outage specific data file -- must be included in the same directory as "crosstie.exe" when running the program. If specific "*.dcy" files stored under a separate sub-directory are desired, they must be moved or copied to the same directory as "crosstie.exe".

If there are any questions, please contact Kevin King at x1858.

ATTACHMENT 2

*****HOLTEC INTERNATIONAL*****

********COMPUTER CODE CROSSTIE********

$Revision: 1.0 $
$Date: 17 Dec 1993 23:30:18 $
$Logfile: C:/RACKHEAT/CONTROL/CROSSTIE.FOV $

FILE: RESULT.TEM

THIS PROGRAM WAS VERIFIED BY THE TEST
PERFORMED DURING SALEM 1R11 OUTAGE, OCTOBER 1993

DESCRIPTION OF YOUR JOB
Program CROSSTIE Verification Case 3

REACTOR SHUTDOWN DATE:
10   2   93
OUTAGE UNIT, TIME TO START CROSS-TIE (HR), AND TEMP   LIMIT(F)
1   496.00   140.30
CCW FLOW(GPM),SFP FLOW(GPM),CCW TEMP(F),& NET WATER VOLUME (ft^3)
2100.00   2040.00   77.00   60000.00
N1,N2,N3,Tao(HR),TaoS(HR)
0   0   0   240.00   60.00
RP(MW), CF, BP1(MWD/MTU), BP2, BP3, UW(Kg)
3411.0   1.0   .00   .00   .00 461.00
FH BUILDING AMBIENT TEMP(F), RELATIVE HUMIDITY(%)
75.50   .60
THE ENDING TIME(HR)
600.00

Heat Exchanger Temperature effectiveness p= .4489

	UNIT 1				UNIT 2			
	(POOL)	(HT-TO-HX)	(HT-LOSS)		(POOL)	(HT-TO-HX)	(HT-LOSS)	
TIME	T1	Q1	Qls1	HX1	T2	Q2	Qls2	HX2
(HR)	(F)	(BTU/HR)	(BTU/HR)		(F)	(BTU/HR)	(BTU/HR)	
.00	81.8	.2215E+07	.57E+05	1	83.2	.2911E+07	.68E+05	1
495.50	81.8	.2215E+07	.57E+05	1	83.2	.2911E+07	.68E+05	0
580.31	81.8	.2215E+07	.57E+05	0	140.3	.1720E+07	.13E+07	1

ATTACHMENT 2

FILE: PLOT.DAT

.00	81.75	83.24
2.00	81.75	83.25
4.00	81.75	83.25
6.00	81.75	83.25
8.00	81.75	83.25
10.00	81.75	83.25
12.00	81.75	83.25
14.00	81.75	83.25
16.00	81.75	83.25
18.00	81.75	83.25
20.00	81.75	83.25
22.00	81.75	83.25
24.00	81.75	83.25
26.00	81.75	83.25
28.00	81.75	83.25
30.00	81.75	83.25
32.00	81.75	83.25
34.00	81.75	83.25
36.00	81.75	83.25
38.00	81.75	83.25
40.00	81.75	83.25
42.00	81.75	83.25
44.00	81.75	83.25
46.00	81.75	83.25
48.00	81.75	83.25
50.00	81.75	83.25
52.00	81.75	83.25
54.00	81.75	83.25
56.00	81.75	83.25
58.00	81.75	83.25
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72.00	81.75	83.25
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76.00	81.75	83.25
78.00	81.75	83.25
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118.00	81.75	83.25

ATTACHMENT 2

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ATTACHMENT 2

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ATTACHMENT 2

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ATTACHMENT 2

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ATTACHMENT 2

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ATTACHMENT 2

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ATTACHMENT 2

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495.00	81.75	83.25
495.50	81.75	83.25
496.00	81.75	83.31
496.50	81.75	83.72
497.00	81.75	84.12
497.50	81.75	84.53
498.00	81.75	84.93
498.50	81.75	85.33
499.00	81.75	85.74
499.50	81.75	86.14
500.00	81.75	86.54
500.50	81.75	86.94
501.00	81.75	87.34
501.50	81.75	87.74
502.00	81.75	88.14
502.50	81.75	88.54
503.00	81.75	88.94
503.50	81.75	89.34
504.00	81.75	89.73
504.50	81.75	90.13
505.00	81.75	90.53
505.50	81.75	90.92
506.00	81.75	91.32
506.50	81.75	91.71

507.00	81.75	92.11
507.50	81.75	92.50
508.00	81.75	92.89
508.50	81.75	93.29
509.00	81.75	93.68
509.50	81.75	94.07
510.00	81.75	94.46
510.50	81.75	94.85
511.00	81.75	95.24
511.50	81.75	95.63
512.00	81.75	96.02
512.50	81.75	96.40
513.00	81.75	96.79
513.50	81.75	97.18
514.00	81.75	97.56
514.50	81.75	97.95
515.00	81.75	98.33
515.50	81.75	98.72
516.00	81.75	99.10
516.50	81.75	99.48
517.00	81.75	99.86
517.50	81.75	100.24
518.00	81.75	100.62
518.50	81.75	101.00
519.00	81.75	101.38
519.50	81.75	101.76
520.00	81.75	102.14
520.50	81.75	102.52
521.00	81.75	102.89
521.50	81.75	103.27
522.00	81.75	103.64
522.50	81.75	104.01
523.00	81.75	104.39
523.50	81.75	104.76
524.00	81.75	105.13
524.50	81.75	105.50
525.00	81.75	105.87
525.50	81.75	106.24
526.00	81.75	106.61
526.50	81.75	106.98
527.00	81.75	107.34
527.50	81.75	107.71
528.00	81.75	108.08
528.50	81.75	108.44
529.00	81.75	108.80
529.50	81.75	109.17
530.00	81.75	109.53
530.50	81.75	109.89
531.00	81.75	110.25
531.50	81.75	110.61
532.00	81.75	110.97
532.50	81.75	111.32
533.00	81.75	111.68
533.50	81.75	112.03
534.00	81.75	112.39
534.50	81.75	112.74
535.00	81.75	113.10
535.50	81.75	113.45
536.00	81.75	113.80
536.50	81.75	114.15

ATTACHMENT 2

537.00	81.75	114.50
537.50	81.75	114.85
538.00	81.75	115.19
538.50	81.75	115.54
539.00	81.75	115.88
539.50	81.75	116.23
540.00	81.75	116.57
540.50	81.75	116.91
541.00	81.75	117.25
541.50	81.75	117.59
542.00	81.75	117.93
542.50	81.75	118.27
543.00	81.75	118.61
543.50	81.75	118.94
544.00	81.75	119.28
544.50	81.75	119.61
545.00	81.75	119.94
545.50	81.75	120.28
546.00	81.75	120.61
546.50	81.75	120.94
547.00	81.75	121.26
547.50	81.75	121.59
548.00	81.75	121.92
548.50	81.75	122.24
549.00	81.75	122.57
549.50	81.75	122.89
550.00	81.75	123.21
550.50	81.75	123.53
551.00	81.75	123.85
551.50	81.75	124.17
552.00	81.75	124.49
552.50	81.75	124.80
553.00	81.75	125.12
553.50	81.75	125.43
554.00	81.75	125.74
554.50	81.75	126.05
555.00	81.75	126.36
555.50	81.75	126.67
556.00	81.75	126.98
556.50	81.75	127.28
557.00	81.75	127.59
557.50	81.75	127.89
558.00	81.75	128.19
558.50	81.75	128.49
559.00	81.75	128.79
559.50	81.75	129.09
560.00	81.75	129.39
560.50	81.75	129.68
561.00	81.75	129.98
561.50	81.75	130.27
562.00	81.75	130.56
562.40	81.75	130.80
562.79	81.75	131.02
563.17	81.75	131.24
563.54	81.75	131.46
563.91	81.75	131.67
564.26	81.75	131.87
564.61	81.75	132.07
564.95	81.75	132.26
565.28	81.75	132.45

ATTACHMENT 2

565.60	81.75	132.63
565.92	81.75	132.81
566.23	81.75	132.98
566.53	81.75	133.15
566.83	81.75	133.31
567.12	81.75	133.48
567.40	81.75	133.63
567.68	81.75	133.79
567.95	81.75	133.93
568.21	81.75	134.08
568.47	81.75	134.22
568.73	81.75	134.36
568.97	81.75	134.49
569.22	81.75	134.63
569.45	81.75	134.75
569.68	81.75	134.88
569.91	81.75	135.00
570.13	81.75	135.12
570.35	81.75	135.24
570.56	81.75	135.35
570.77	81.75	135.46
570.97	81.75	135.57
571.17	81.75	135.68
571.37	81.75	135.78
571.56	81.75	135.88
571.75	81.75	135.98
571.93	81.75	136.08
572.11	81.75	136.17
572.28	81.75	136.27
572.45	81.75	136.36
572.62	81.75	136.44
572.79	81.75	136.53
572.95	81.75	136.61
573.10	81.75	136.70
573.26	81.75	136.78
573.41	81.75	136.85
573.56	81.75	136.93
573.70	81.75	137.01
573.84	81.75	137.08
573.98	81.75	137.15
574.12	81.75	137.22
574.25	81.75	137.29
574.38	81.75	137.36
574.51	81.75	137.42
574.64	81.75	137.49
574.76	81.75	137.55
574.88	81.75	137.61
575.00	81.75	137.67
575.11	81.75	137.73
575.22	81.75	137.79
575.33	81.75	137.84
575.44	81.75	137.90
575.55	81.75	137.95
575.65	81.75	138.00
575.75	81.75	138.06
575.85	81.75	138.11
575.95	81.75	138.15
576.05	81.75	138.20
576.14	81.75	138.25
576.23	81.75	138.30

576.32	81.75	138.34
576.41	81.75	138.39
576.50	81.75	138.43
576.58	81.75	138.47
576.67	81.75	138.51
576.75	81.75	138.55
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576.91	81.75	138.63
576.98	81.75	138.67
577.06	81.75	138.71
577.13	81.75	138.75
577.20	81.75	138.78
577.27	81.75	138.82
577.34	81.75	138.85
577.41	81.75	138.88
577.48	81.75	138.92
577.54	81.75	138.95
577.61	81.75	138.98
577.67	81.75	139.01
577.73	81.75	139.04
577.79	81.75	139.07
577.85	81.75	139.10
577.91	81.75	139.13
577.97	81.75	139.16
578.02	81.75	139.19
578.08	81.75	139.21
578.13	81.75	139.24
578.18	81.75	139.27
578.23	81.75	139.29
578.28	81.75	139.32
578.33	81.75	139.34
578.38	81.75	139.36
578.43	81.75	139.39
578.48	81.75	139.41
578.52	81.75	139.43
578.57	81.75	139.45
578.61	81.75	139.47
578.65	81.75	139.50
578.69	81.75	139.52
578.74	81.75	139.54
578.78	81.75	139.56
578.82	81.75	139.58
578.86	81.75	139.59
578.89	81.75	139.61
578.93	81.75	139.63
578.97	81.75	139.65
579.00	81.75	139.67
579.04	81.75	139.68
579.07	81.75	139.70
579.11	81.75	139.72
579.14	81.75	139.73
579.17	81.75	139.75
579.21	81.75	139.76
579.24	81.75	139.78
579.27	81.75	139.80
579.30	81.75	139.81
579.33	81.75	139.82
579.36	81.75	139.84
579.39	81.75	139.85
579.41	81.75	139.87

ATTACHMENT 2

579.44	81.75	139.88
579.47	81.75	139.89
579.49	81.75	139.90
579.52	81.75	139.92
579.54	81.75	139.93
579.57	81.75	139.94
579.59	81.75	139.95
579.62	81.75	139.96
579.64	81.75	139.98
579.66	81.75	139.99
579.69	81.75	140.00
579.71	81.75	140.01
579.73	81.75	140.02
579.75	81.75	140.03
579.77	81.75	140.04
579.79	81.75	140.05
579.81	81.75	140.06
579.83	81.75	140.07
579.85	81.75	140.08
579.87	81.75	140.09
579.89	81.75	140.10
579.91	81.75	140.10
579.93	81.75	140.11
579.94	81.75	140.12
579.96	81.75	140.13
579.98	81.75	140.14
579.99	81.75	140.15
580.01	81.75	140.15
580.03	81.75	140.16
580.04	81.75	140.17
580.06	81.75	140.18
580.07	81.75	140.18
580.09	81.75	140.19
580.10	81.75	140.20
580.11	81.75	140.20
580.13	81.75	140.21
580.14	81.75	140.22
580.16	81.75	140.22
580.17	81.75	140.23
580.18	81.75	140.24
580.19	81.75	140.24
580.21	81.75	140.25
580.22	81.75	140.25
580.23	81.75	140.26
580.24	81.75	140.26
580.25	81.75	140.27
580.26	81.75	140.28
580.28	81.75	140.28
580.29	81.75	140.29
580.30	81.75	140.29
580.31	81.75	140.30
580.32	81.75	140.29
580.33	81.76	140.21
580.34	81.77	140.10
580.36	81.78	139.96
580.38	81.79	139.78
580.41	81.81	139.54
580.45	81.84	139.24
580.51	81.87	138.84
580.58	81.91	138.33

580.66	81.97	137.67
580.78	82.04	136.83
580.93	82.13	135.77
581.12	82.25	134.43
581.36	82.40	132.77
581.67	82.59	130.74
582.07	82.83	128.30
582.57	83.14	125.38
583.07	83.44	122.65
583.57	83.75	120.10
584.07	84.05	117.72
584.57	84.36	115.50
585.07	84.67	113.42
585.57	84.97	111.47
586.07	85.27	109.66
586.57	85.58	107.96
587.07	85.88	106.37
587.57	86.19	104.88
588.07	86.49	103.50
588.57	86.79	102.20
589.07	87.09	100.98
589.57	87.39	99.84
590.07	87.70	98.78
590.57	88.00	97.78
591.07	88.30	96.85
591.57	88.60	95.98
592.07	88.90	95.17
592.57	89.20	94.40
593.07	89.50	93.69
593.57	89.80	93.02
594.07	90.09	92.40
594.57	90.39	91.81
595.07	90.69	91.26
595.57	90.99	90.75
596.07	91.28	90.27
596.57	91.58	89.82
597.07	91.88	89.40
597.57	92.17	89.01
598.07	92.47	88.64
598.57	92.76	88.30
599.07	93.05	87.97
599.57	93.35	87.67
600.07	93.64	87.39

S-C-SF-MCS-0113 SHT. 1
APPX 2
ATT. 1

HOLTEC
INTERNATIONAL

VERIFICATION AND VALIDATION DOCUMENTATION FOR COMPUTER PROGRAM CROSSTIE

for

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

by

Yu Wang, Ph.D.
Holtec International

Holtec Project 20890
Holtec Report HI-931099

Safety Related
Report Category: A

HOLTEC
INTERNATIONAL

REVIEW AND CERTIFICATION LOG

DOCUMENT NAME:	Verification and Validation Documentation for Computer Program CROSSTIE
HOLTEC DOCUMENT I.D. NUMBER:	HI-931099
HOLTEC PROJECT NUMBER:	20890
CUSTOMER/CLIENT:	Public Service Electric and Gas Company

REVISION BLOCK				
ISSUE NUMBER	AUTHOR & DATE	REVIEWER & DATE	QA MANAGER & DATE	APPROVED* & DATE
ORIGINAL	12/28/93	IR 12/29/93	MS 12/29/93	12/28/93
REVISION 1				
REVISION 2				
REVISION 3				
REVISION 4				
REVISION 5				
REVISION 6				

This document conforms to the requirements of the design specification and the applicable sections of the governing codes.

Note: Signatures and printed names are required in the review block.

* Must be Project Manager or his designee.

TABLE OF CONTENTS

1.0	REQUIREMENTS	1-2
2.0	DESIGN	2-1
2.1	Heat Exchanger Data	2-2
2.2	Decay Heat Calculations	2-2
2.3	Heat Loss Calculation	2-4
2.4	Inital Temperatures	2-5
2.5	Exchanger Isolation Condition	2-5
2.6	Program Acceptance Criteria	2-6
3.0	IMPLEMENTATION	3-1
4.0	EXPERIMENT	4-1
4.1	Test Setup	4-1
4.2	Test Results	4-8
5.0	PROGRAM VALIDATION	5-1
5.1	Input Data	5-1
5.2	Program Verification	5-8
Appendix A:	Test Data	(224 pages)
Appendix B:	Test Instrument Calibration	(19 pages)

1.0 REQUIREMENTS

Program CROSSTIE is developed for Salem Generating Station Units 1 and 2. This report provides the necessary verification and validation for the program in compliance with the applicable Holtec QA requirements. The prime verification approach will be the experimentation. The program will be verified against the site measurements obtained during Salem 1R11 outage.

The principal objectives of this program are summarized in four points:

(i) Predict the refueling cycle when the cross-tie operation is not possible with 120°F maximum operating temperature limit.

(ii) Develop a predictive tool which enables PSE&G to adjust the system variable to extend the cross-tie operation further into the future without upgrading the system.

(iii) Provide the plant reactor engineering a user friendly code to predict spent fuel pool water temperatures and to manage the cross-tie operation with *minimum* input data requirements.

(iv) Provide the plant mechanical engineering group with the necessary software capability to *quantify system changes* which might be required in the future to deal with cross-tie operation.

This computer program will have the following features:

(i) The heat load from the fuel presently stored in both pools will be able to be computed precisely using the actual fuel burnups for *each* fuel assembly. When the user enters the reactor shutdown date and time for a specific outage, the heat load from the stored inventory will automatically be updated.

(ii) The SFP and CCW flow rates will be set at design values to which the program will default unless new values are supplied. The CCW inlet temperature, Fuel Handling Building ambient air temperature and relative humidity ratio will be entered as constants.

(iii) The manner of fuel discharge to the pool (number of bundles per day) and fuel specific power which will occur in the immediate future will be inputted.

(iv) The threshold temperature to initiate a switchover will be set at 120°F unless the user overrides it with another number.

(v) The program will output the maximum time between cross-tie switchovers and bulk pool temperature profiles. The user can study the effect of changing the threshold temperature to arrive at the best cross-tie operation strategy.

2.0 DESIGN

To meet the requirements described in Section 1.0, the following analytical components need to be developed for the program:

a) Decay heat calculations.
b) Heat loss calculations.
c) Heat exchanger performance.
d) Numerical algorithm for the non-linear differential equations.

The bulk spent fuel pool temperature evaluation is performed by constructing a heat balance model with the heat generation source term derived from the stored fuel assemblies, and the heat removal term equal to the heat duty of the heat exchanger expressed in terms of its temperature effectiveness.

Referring to the spent fuel pool/cooler system, the governing differential equation can be written by utilizing conservation of energy:

$$C \frac{dT}{d\tau} = Q_L - Q_{HX} \tag{2-1}$$

$$Q_L = P_{cons} + Q(\tau_o, \tau_s) - Q_{EV}(T, t_a)$$

where:

C:	Thermal capacitance of the pool, Btu/°F
Q_L:	Heat load to the heat exchanger, Btu/hr
$Q(\tau_o,\tau_s)$	Heat generation rate from freshly discharged fuel, which is a specified function of time after reactor shutdown τ_s and reactor operating time τ_o, Btu/hr

$P_{cons} = \xi\, P_o$: Heat generation rate from the inventory spent fuel storage-background heat load, Btu/hr

P_o: Average specific power of fuel assemblies, Btu/hr

Q_{HX}: Heat removal rate by the heat exchanger, Btu/hr

$Q_{EV}(T,t_a)$: Heat loss to the surroundings, which is a function of pool temperature T and ambient temperature t_a, Btu/hr

2.1 Heat Exchanger Data

Q_{HX} is a non-linear function of time. It can, however, be written in terms of effectiveness p as follows:

$$Q_{HX} = W_t\, C_t\, p\, (T - t_i) \tag{2-2}$$

where:

W_t: Coolant flow rate, lb/hr
C_t: Coolant specific heat, Btu/lb - °F
p: Temperature effectiveness
T: Pool water temperature, °F
t_i: Coolant inlet temperature, °F

The temperature effectiveness p is defined as

$$p = \frac{t_o - t_i}{T - t_i} \tag{2-3}$$

where t_o is the coolant outlet temperature. Based on fuel pool heat exchanger data, p can be obtained.

2.2 Decay Heat Calculations

$Q(\tau_o,\tau_s)$ is specified according to the provisions of USNRC Branch Technical Position ASB9-2, "Residual Decay Energy for Light Water Reactors for Long Term Cooling", Rev. 2, July, 1981.

For finite reactor operating time (τ_o) the fraction of operating power, P/P_o (τ_o, τ_s), to be used for the fission product decay power at a time τ_s after shutdown may be calculated as follows:

$$\frac{P}{Po}(\infty, \tau_s) = \frac{1}{200} \sum_{n=1}^{n=11} A_n \exp(-a_n \tau_s) \tag{2-4}$$

$$\frac{P}{Po}(\tau_o, \tau_s) = (1 + K) \frac{P}{Po}(\infty, \tau_s) - \frac{P}{Po}(\infty, \tau_o + \tau_s) \tag{2-5}$$

where:

Po	=	operating power per fuel assembly
ξ	=	P/P_o = fraction of operating power
τ_o	=	cumulative reactor operating time, seconds
τ_s	=	time after shutdown, seconds
K	=	uncertainty factor; NRC recommends 0.2 for $o \le \tau_s < 10^3$ and 0.1 for $10^3 \le \tau_s \le 10^7$ and will be determined based on the test calibration.
A_n, a_n	=	fit coefficients having the following values:

n	A_n	a_n (sec^{-1})
1	0.5980	1.772×10^{0}
2	1.6500	5.774×10^{-1}
3	3.1000	6.743×10^{-2}
4	3.8700	6.214×10^{-3}
5	2.3300	4.739×10^{-4}
6	1.2900	4.810×10^{-5}
7	0.4620	5.344×10^{-6}
8	0.3280	5.716×10^{-7}
9	0.1700	1.036×10^{-7}
10	0.0865	2.959×10^{-8}
11	0.1140	7.585×10^{-10}

Reactor operating time, τ_o is determined from the assumed burnup and τ_s is determined upon the actual discharge dates.

$Q(\tau_o, \tau_s)$ is a function of time after reactor shutdown, number of assemblies, and reactor operating time τ_o. During the fuel transfer, the heat load in the pool will increase with respect to the rate of fuel transfer and equals $Q(\tau_o, \tau_s)$ after the fuel transfer.

2.3 Heat Loss Calculation

Q_{EV} is a non-linear function of pool temperature and ambient temperature. Q_{EV} contains the heat evaporation loss through the pool surface, natural convection from the pool surface and heat radiation from the pool surface. The conduction heat loss through the spent fuel pool walls is not included in the analytical model; however, it is considered in the correction factor α, which will be determined in the test calibration. The heat loss can be expressed as:

$$Q_{EV} = \alpha \left(m \lambda A_s + h_C A_s \theta + \epsilon \sigma A_s (T^4 - t_a^4) \right) \tag{2-6}$$

where:

m:	Mass evaporation rate, lb/hr - ft^2
λ:	Latent heat of pool water, Btu/lb
A_s:	Pool surface area, ft^2
h_c:	Convection heat transfer coefficient at pool surface, Btu/hr - ft^2 - °F
$\theta = T - t_a$:	The temperature difference between pool water and ambient air, °F
ϵ:	Emissivity of water = 0.94
σ:	0.1713×10^{-8} Btu/hr - ft^2 - °F^4
α:	Correction factor to be determined by the experiment.

The mass evaporation rate m can be obtained as a non-linear function of θ. We, therefore, have

$$m = h_D(\theta)\,(W_{ps} - W_a) \tag{2-7}$$

where:

W_{ps}: Humidity ratio of saturated moist air at pool water surface temperature T, lbs. of water vapor per lb. of dry air.

W_a: Humidity ratio of moist air at ambient temperature t_a, lbs. of water vapor per lb. of dry air.

$h_D(\theta)$: Mass transfer coefficient at pool water surface. h_D is a non-linear function of θ, lb/hr - ft^2.

2.4 Initial Temperatures

Equation (2-1) is solved as an initial value problem by noting that the pool is at a steady state condition such that the cooler heat removal rate must equal the heat generation rate from previously discharged assemblies. Hence:

$$W_t\, C_t\, p\, (T_{in} - t_i) = P_{cons} - Q_{EV}$$

where:

T_{in}: Coincident pool water temperature (initial value before beginning of discharge)

The above equation yields:

$$T_{in} = \frac{P_{cons} - Q_{EV}}{W_t\, C_t\, p} + t_i$$

2.5 Exchanger Isolation Condition

When heat exchanger is isolated, the governing enthalpy balance equation for this condition can be written as

$$C \frac{dT}{d\tau} = P_{cons} + Q(\tau) - Q_{EV} \tag{2-8}$$

2.6 Program Acceptance Criteria

Program CROSSTIE will be validated by comparing runs with experimental data. Experimental data is to be collected from both Salem spent fuel pools and Unit 2 spent fuel pool cooling system during the scheduled 1R11 outage. Calculated water temperatures from program CROSSTIE will be compared to experimental data water temperatures over a defined time period. The acceptability of the program will be determined through engineering judgement based on the percent deviation between the measurements and the calculated results.

3.0 IMPLEMENTATION

The program CROSSTIE is developed using FORTRAN. The Salem specific heat exchanger parameters and the spent fuel pool geometry are built into the program. The program requires the following input data files:

UNIT1.DCY:	Burnup and discharge data for the Unit 1 spent fuel inventory.
UNIT2.DCY:	Burnup and discharge data for the Unit 2 spent fuel inventory.
RFILE:	Name will be specified by the user. The file contains input parameters for a specific outage.
	Note: RFILE contains data for a specific outage and the fuel inventory data inputted in files UNIT1.DCY AND UNIT2.DCY should cover all prior discharges.

A sample of the input files is attached.

The program also requires the following inputs during the execution of the program:

RFILE Name

TAVC:	Time after-reactor-shutdown to start crosstie, hrs.
TL:	Pool water temperature limit for switchover, °F
TI:	CCW coolant temperature, °F
TEND:	Ending time for integration, hrs.

CROSSTIE will generate the following output files:

RESULT.TEM:	Hard copy of input and output results.
PLOT.DAT:	Containing time coordinates, Units 1 and 2 pool temperatures for plotting.
UNIT1.HTL:	Decay heat results from Unit 1 spent fuel inventory.
UNIT2.HTL:	Decay heat results from Unit 2 spent fuel inventory.

INPUT FILE #1 & #2

BURNUP FOR THE FUEL IN THE SFP
SALEM UNIT 1 & 2

File Name: "Unit1.dcy"
"Unit2.dcy"

Cycle No.	Discharge Date	Batch No.	No. of FAS	Wt. Assy KgU	Exposure MWD/MTU	Power MW(t)

Note: Batch - Group of assemblies having same burnup. It is numbered sequantialy from 1 for each cycle.

Power - Reactor power in MW(t).

Discharge Date- Enter in the format of MM,DD,YY. Example: 09,22,93

EXAMPLE DATA FILE:

1	01,21,83	1	56	461.0	18400	3411
1	01,21,83	2	12	461.0	19700	3411
2	10,04,84	1	09	461.0	20700	3411
2	10,04,84	2	52	461.0	23900	3411
2	10,04,84	3	07	461.0	21600	3411
3	10,02,86	1	53	461.0	33400	3411
3	10,02,86	2	04	461.0	21600	3411
4	08,31,88	1	02	461.0	32200	3411
4	08,31,88	2	30	461.0	37000	3411
4	08,31,88	3	42	461.0	37400	3411
4	08,31,88	4	03	461.0	38500	3411
5	03,31,90	1	09	461.0	36000	3411
5	03,31,90	2	08	461.0	29700	3411
5	03,31,90	3	12	461.0	41500	3411
5	03,31,90	4	01	461.0	25300	3411
5	03,31,90	5	45	461.0	36500	3411
6	11,09,91	1	33	461.0	42400	3411
6	11,09,91	2	28	461.0	36400	3411
6	11,09,91	3	08	461.0	32300	3411
7	03,16,93	1	08	461.0	34800	3411
7	03,16,93	2	08	461.0	39600	3411
7	03,16,93	3	01	461.0	29300	3411
7	03,16,93	4	01	461.0	43100	3411
7	03,16,93	5	08	461.0	39900	3411
7	03,16,93	6	39	461.0	36400	3411
7	03,16,93	7	04	461.0	30400	3411

INPUT FILE #3
SALEM UNITS 1&2 CROSS-TIE EVALUATION
INPUT INSTRUCTION

LINE 1:

FIN:	DESCRIPTION OF YOUR JOB

LINE 2:

MTD(3):	REACTOR SHUTDOWN DATE. MTD(1)=MONTH, MTD(2)=DAY, MTD(3) = YEAR.

LINE 3:

ND:	UNIT WHICH IS GOING TO BE IN OUTAGE

LINE 4:

Wt:	SPENT FUEL POOL COOLING HEAT EXCHANGER COOLANT (CCW) FLOW RATE, GPM (DESIGN=3000 GPM)
Ws:	SPENT FUEL POOL WATER FLOW RATE, GPM (DESIGN=2280GPM; 1R11 MEASUREMENT: UNIT1=2400 GPM, UNIT2=2000 GPM)
V:	NET WATER VOLUME IN THE SPENT FUEL POOL AND THE TRANSFER POOL

LINE 5:

N1:	NO OF FAS IN THE BATCH 1 OF THE DISCHARGE
N2:	NO OF FAS IN THE BATCH 2 OF THE DISCHARGE
N3:	NO OF FAS IN THE BATCH 3 OF THE DISCHARGE
TAO:	DECAY TIME BEFORE TRANSFER FOR THE 1st DISCHARGE,HRS
TAOS:	TOTAL FUEL TRANSFER TIME FOR THE DISCHARGE, HRS

LINE 6:

RP:	REACTOR RATED POWER, MW(t)
CF:	CAPACITY FACTOR OF THE LAST 4 MONTHS BEFORE THE LATEST SHUTDOWN
BP1:	AVERAGE BURNUP FOR THE ASSEMBLIES IN BATCH 1
BP2:	AVERAGE BURNUP FOR THE ASSEMBLIES IN BATCH 2
BP3:	AVERAGE BURNUP FOR THE ASSEMBLIES IN BATCH 3
UW:	ASSEMBLY AVERAGE URANIUM WEIGHT

LINE 7:

TDRY:	AMBIENT AIR TEMPERATURE (DRY BULB) IN THE FUEL HANDLING BUILDING, F
WR:	RELATIVE HUMIDITY IN THE FUEL HANDLING BUILDING, %

EXAMPLE INPUT:

```
Salem cross-tie for Unit 1 outage, 10/2/93
10,02,93
1
2100, 2040, 59000
0,0,0,240.,60.
3411.,1.0,40300.,43200.,40000.,461.0
74., 0.33
```

4.0 EXPERIMENT

An experimental program to calibrate program CROSSTIE was jointly undertaken by PSE&G and Holtec International. Data was collected at both Salem spent fuel pools and Unit 2 spent fuel pool cooling system during the scheduled 1R11 outage in the timeframe October-November, 1993. The test instruments were installed by the Research and Testing Laboratory of PSE&G. The instrument calibration data is attached in Appendix B of this report.

4.1 Test Setup

Measurements are connected to four data acquisition computers. The corresponding data collected are named "DB1", "DB2", "DB3", and "DB4", respectively. DB1 contains all the measurement channels from the Unit 1 pool; DB2 contains all the measurement channels from Unit 2 pool; DB3 contains measurement channels for the Unit 2 SFHX; and DB4 contains the measurement channels for both Unit 1 and Unit 2 spent fuel water flows. The readings on the ambient air temperature and the relative humidity of the Fuel Handling Building are done manually. The instrument locations in the spent fuel pool and the associated data acquisition channels are described below and shown in Figures 4.1 to 4.4. The instrument locations for the fuel pool cooling systems are shown in Figure 4.5a.

a. Unit 1 Spent Fuel Pool Temperature

- Suction from pool (DB1, CH 1,2)
- Discharge to pool (DB1, CH 3,4)
- Grid location CC-14, 5' above fuel rack (DB1, CH 5,6)
- Grid location CC-14, 2' below water surface (DB1, CH 7,8)
- Grid location A-35, 5' above fuel rack (DB1, CH 9,10)
- Grid location A-35, 2' below water surface (DB1, CH 11,12)
- Near existing station monitor probe (TIC-651) (DB1, CH 13)

b. Unit 2 Spent Fuel Pool Temperature

- Suction from pool (DB2, CH 1, 2)
- Discharge to pool (DB2, CH 3,4)
- Grid location D-36, 5' above fuel rack (DB2, CH 5,6)
- Grid location D-36, 2' below water surface (DB2, CH 7,8)
- Grid location DD-10, 5' above fuel rack (DB2, CH 9,10)
- Grid location DD-10, 2' below water surface (DB2, CH 11,12)
- Near existing station monitor probe (TIC-651) (DB2, CH 13)
- Air near water surface (DB2, CH 14)

c. Spent Fuel Temperature at Inlet of Unit 2 SFHX

- Used a surface style thermocouple with a range of 32-200°F near inlet to SFHX. (DB3, CH 1)

d. Spent Fuel Temperature at Outlet of Unit 2 SFHX

- Temporarily removed local temperature indicator at instrument location TI-653. Installed a thermocouple with a range of 32-200°F. (DB3, CH 7)
- Installed a surface style thermocouple with a range of 32-200°F near outlet from SFHX (DB3, CH 2)

e. Unit 1 Spent Fuel Flow

- Installed a Panametric System Flow Meter, or equivalent, on 8" line 1-SF-50 (DB4, CH 1)

f. Unit 2 Spent Fuel Flow

- Installed a Panametric System Flow Meter, or equivalent, on 8" line 2-SF-59 (DB4, CH 2)

  (Performed a zero flow calibration on the flow meter.)

g. Component Cooling <u>Inlet</u> Temperature to Unit 2 SFHX

1) 21CCHX Outlet Temperature

- Installed a thermocouple with a range of 32-200°F, at location TA9286, along with existing instrumentation (DB3, CH 5)

2) 22CCHX Outlet Temperature XEK 5/12/94 per telecon

9

- Installed a thermocouple with a range of 32-200°F, at location TA~~8~~264, along with existing instrumentation (DB3, CH 6)

3) Installed a surface style thermocouple with a range of 32-200° near inlet to SFHX (DB3, CH 3)

h. Component Cooling Outlet Temperature from Unit 2 SFHX

- Temporarily removed local temperature indicator at instrument location TI-604. Installed a thermocouple with a range of 32-200°F.

- Installed a surface style thermocouple with a range of 32-200°F near outlet from SFHX (DB3, CH 4).

i. Component Cooling Flow through SFHX

- Installed a Differential Pressure Transmitter, 4-20 mA, in parallel with FE-603, at outlet of Unit 2 SFHX (DB3, CH 9,10)

j. Service Water Temperature

- Installed a thermocouple with a range of 32-200°F, at location TT-14726 (DB3, CH 19,20)

k. Unit 1 Fuel Handling Building Temperature/Relative Humidity

- Installed three Solomat temperature/relative humidity probes, or equivalent, with a range of 32-200°F/10-90%, in the area around the Unit 1 Spent Fuel Pool (manual reading)

l. Unit 2 Fuel Handling Building Temperature/Relative Humidity

- Installed three Solomat temperature/relative humidity probes, or equivalent, with a range of 32-200°F/10-90%, in the area around the Unit 2 Spent Fuel Pool (manual reading)

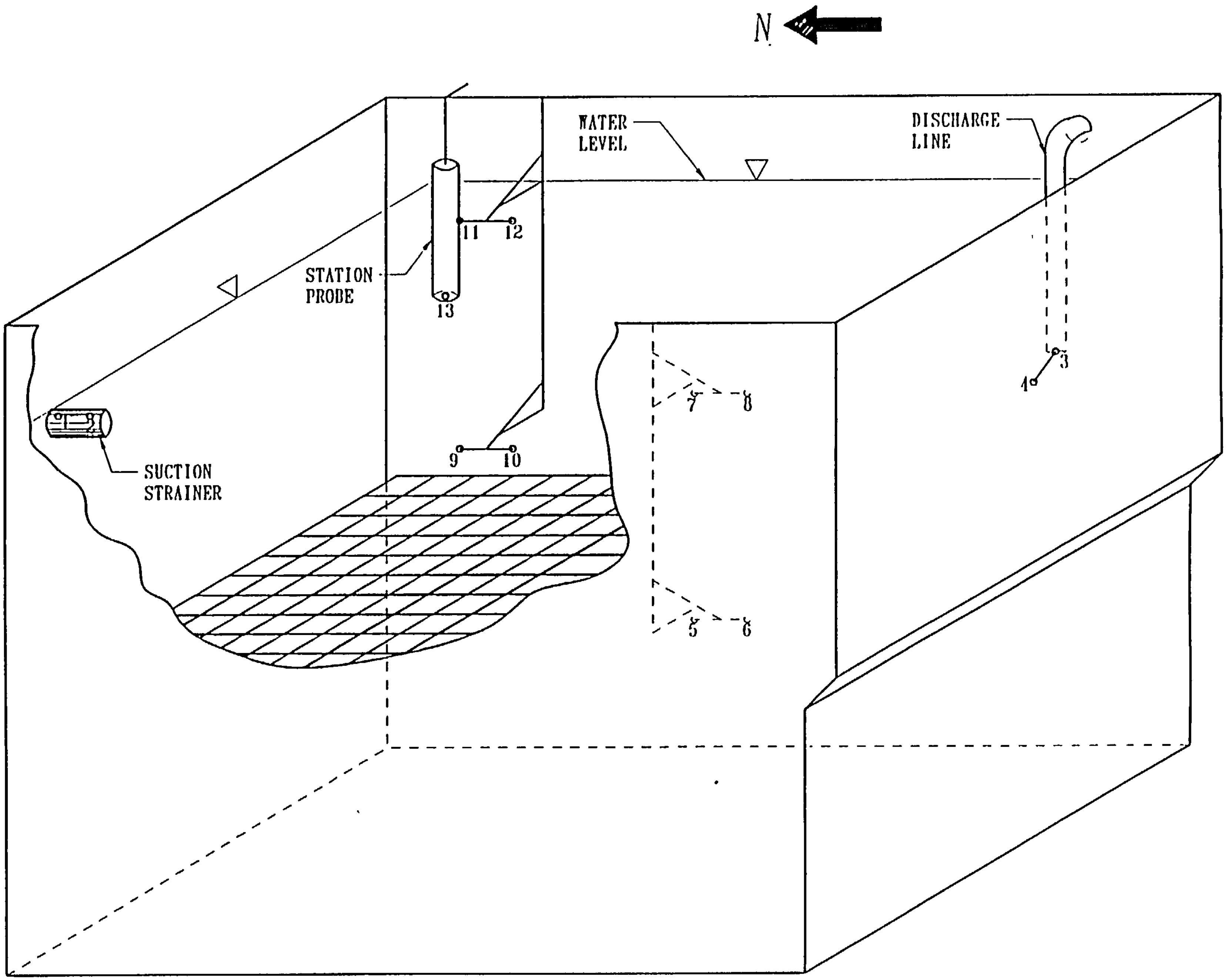

FIGURE 4.1
ISOMETRIC VIEW OF TEMPERATURE PROBE LOCATIONS SALEM UNIT 1

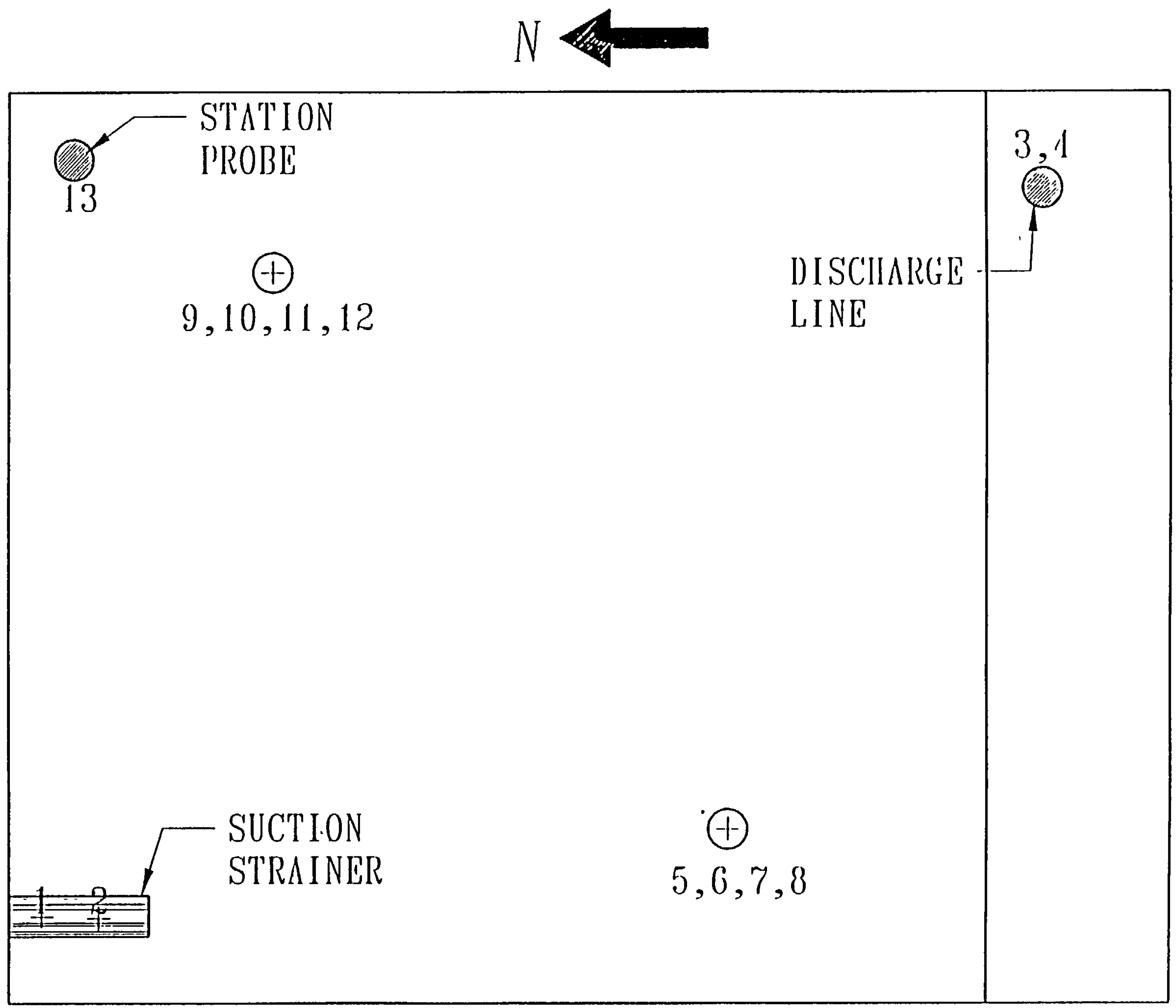

FIGURE 4.2
PLAN VIEW OF TEMPERATURE PROBE LOCATIONS SALEM UNIT 1

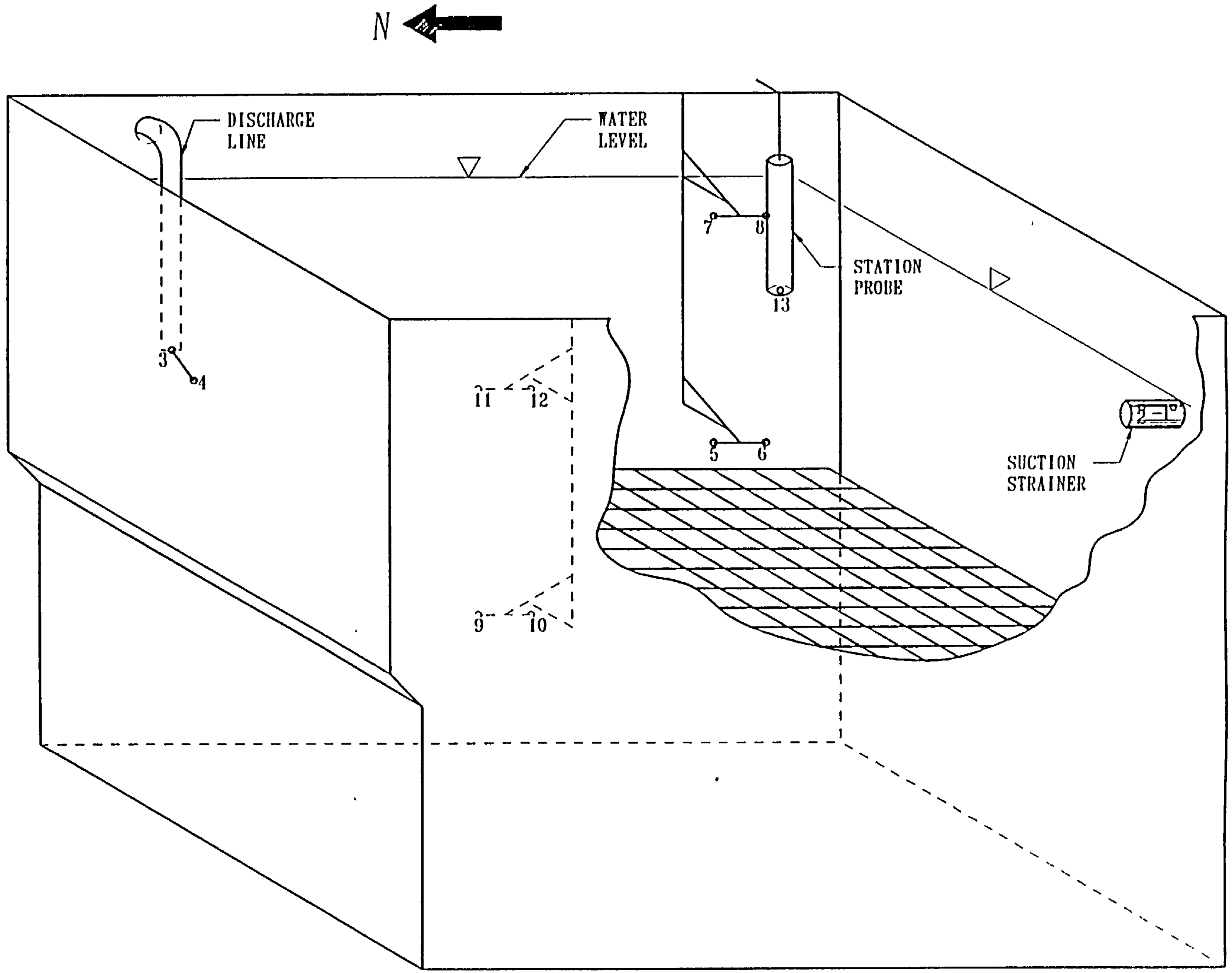

FIGURE 4.3
ISOMETRIC VIEW OF TEMPERATURE PROBE LOCATIONS SALEM UNIT 2

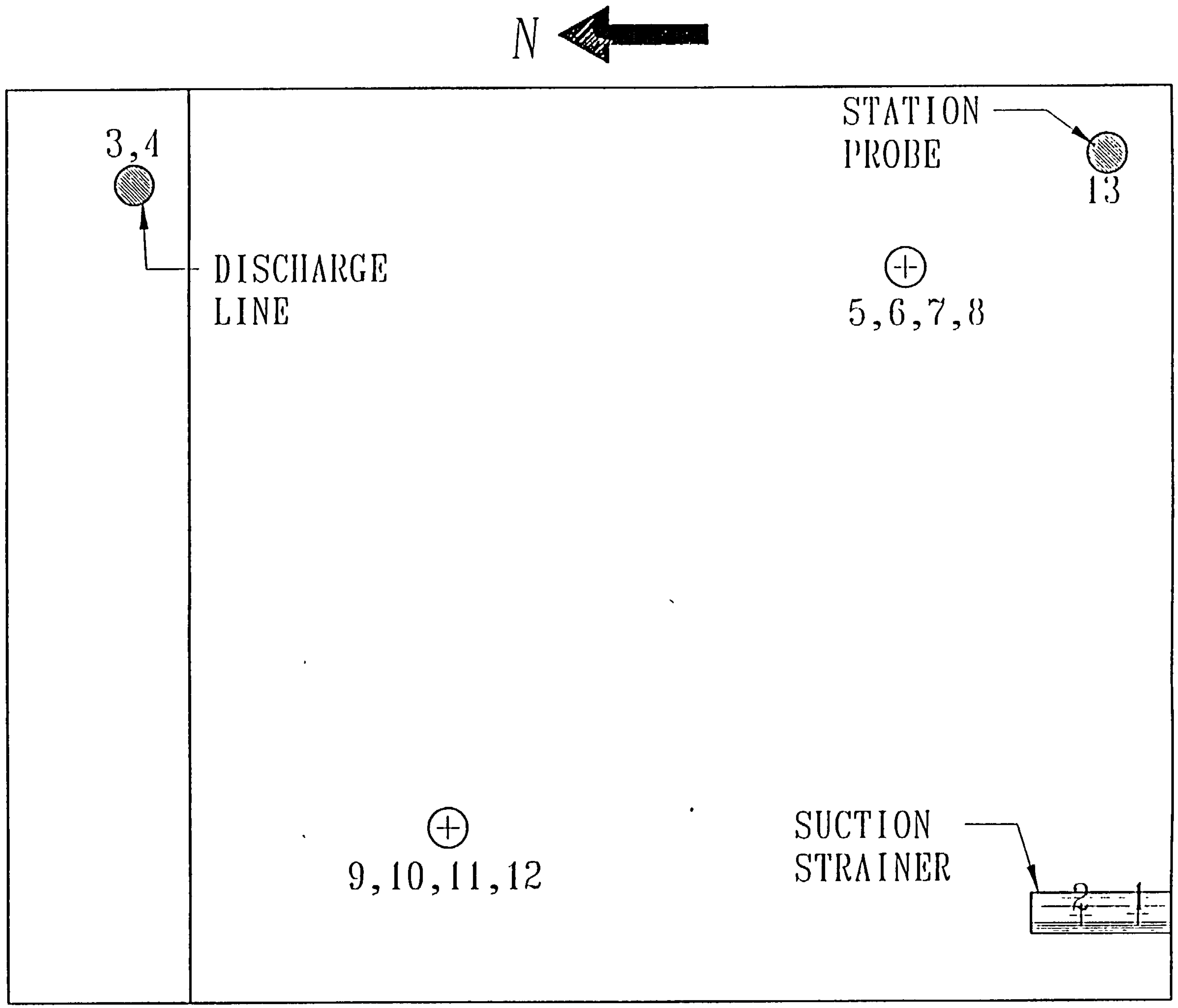

FIGURE 4.4
PLAN VIEW OF TEMPERATURE PROBE LOCATIONS SALEM UNIT 2

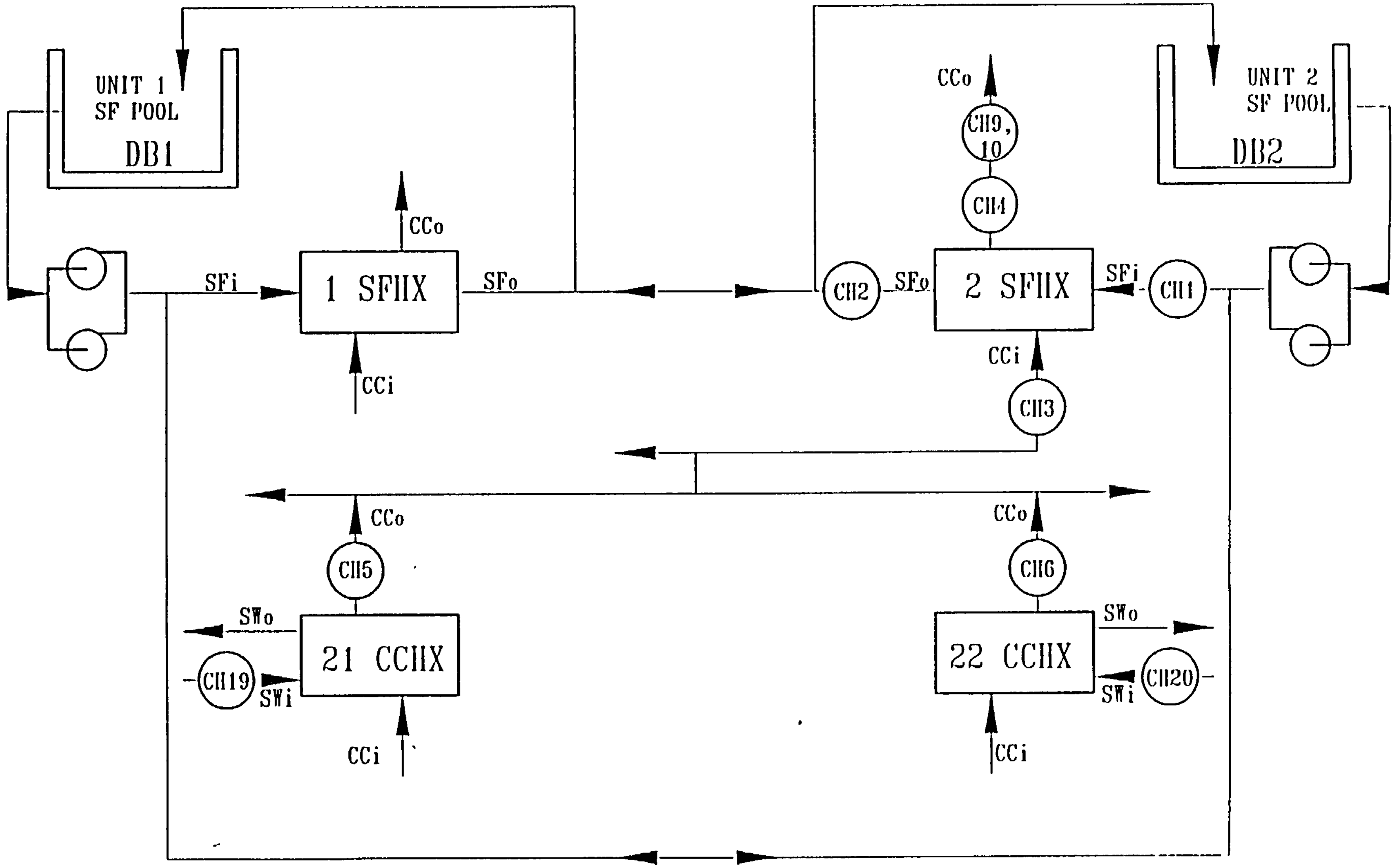

FIGURE 4.5a INSTRUMENT CHANNEL LOCATIONS FOR DB3

4.2 Test Results

The original plan for the test was to measure the pool temperatures, and other parameters, when the Unit 1 SFHX was out of service and the Unit 2 SFHX was cycled between the Unit 1 and Unit 2 pools, utilizing the cross-tie for the 1R11 outage. Heatup and cooldown data could then be obtained for both pools. However, due to a high heat load with the Unit 1 core unload, the Unit 1 pool could not be isolated from cooling. Therefore, during the cross-tie the Unit 1 SFHX was out of service, the Unit 1 pool was being cooled by Unit 2 SFHX via the cross-tie, and the Unit 2 pool was heating up. The Unit 2 pool was allowed to heat up to 140° F, at which time the Unit 1 SFHX was returned to service, and normal cooling restored to both pools.

The theory was developed based on the overall average bulk temperature, and the operation was controlled based on the station monitor probe reading. Observations were made on the pool water temperature distribution during different phases of the cross-tie, namely, steady state cooling, heating up without cooling, and cooling down when resuming cooling.

A close perusal of the pool temperature data shows that (i) during the heating up the maximum temperature difference between different measurement points in spent fuel pool is less than 1°F; (ii) during the steady state cooling, the temperature differences between different locations are less than 1°F.

After resuming forced cooling, the Unit 2 pool temperature cooled down sharply from 140°F to 80°F, at about 2.5°F/hr. As a result: (i) the maximum temperature difference between the bulk water temperature and the station probe is increased to about 5°F; (ii) the temperature difference between water surface and the bottom is less than 25°F. The surface temperature is higher, since coolant has higher density and tends to "sink".

The SFP bulk temperatures were calculated individually by taking nodal averages of temperature:

$$T = \frac{\sum_{i=1}^{n} T_i}{n}$$

where:

n = number of the measurement points

T_i = temperature value at the measurement point i (i = 1,2,3...n except for the discharge location)

Average pool surface/bottom/station temperature was calculated by

$$T_s = \frac{\sum_{i=1}^{m} T_i}{m}$$

where:

m = number of local measurement points

T_i = test value at surface/bottom/station location i,i = 1,2...m

Hard copy of all raw test data and the processed bulk temperatures at surface, bottom, and station probe locations are attached in Appendix A.

The bulk temperatures for both Units 1 and Unit 2 are plotted vs. time after reactor shutdown in Figures 4.5 through 4.12. The fuel handling building ambient air temperature and relative humidity ratio during the cross-tie are also plotted vs. time in Figures 4.13 to 4.16.

HOLTEC INTERNATIONAL

SALEM OUTAGE 1R11, UNIT 1 FUEL POOL WATER TEMPERATURE

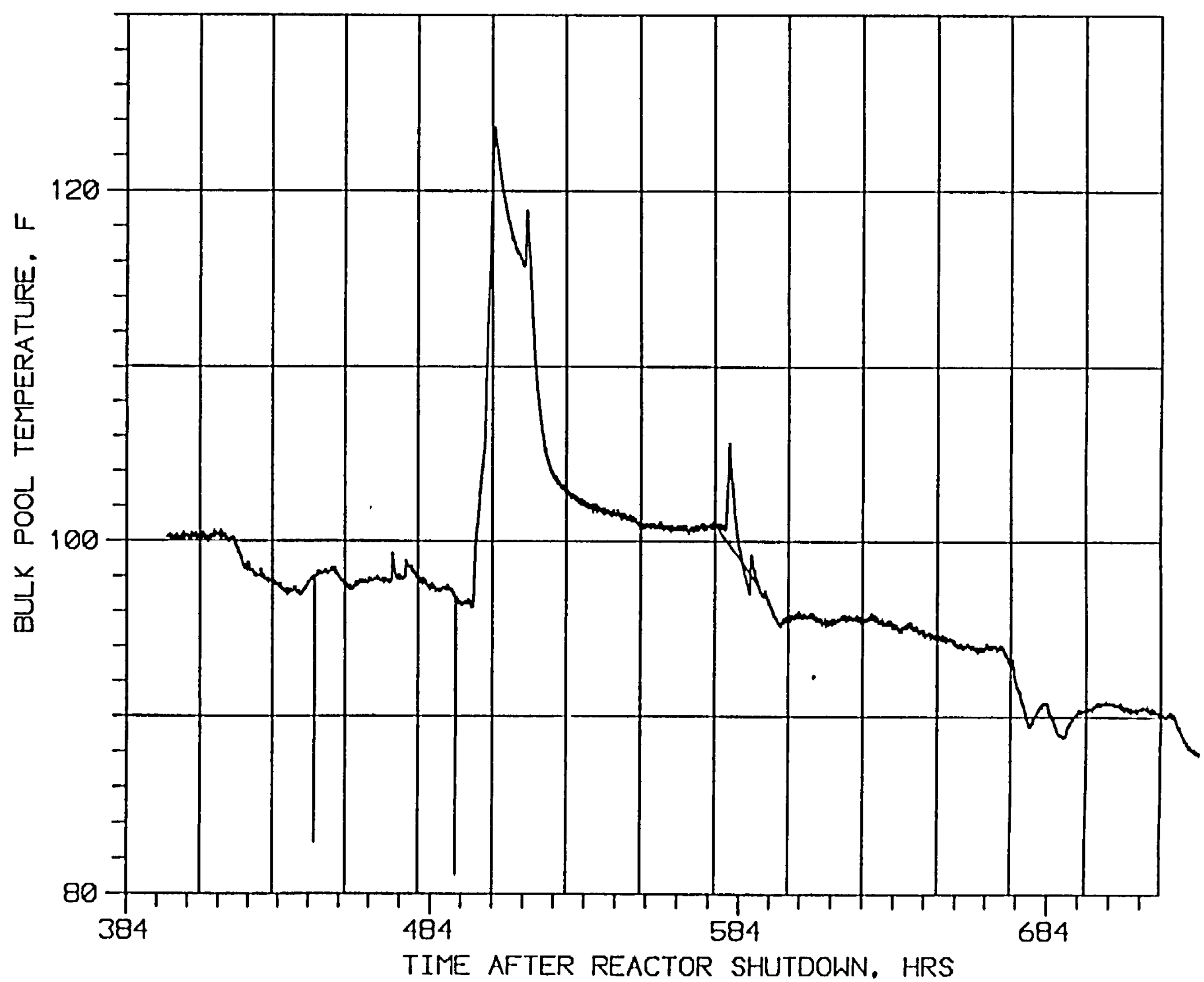

FIGURE 4.5

HOLTEC INTERNATIONAL

SALEM OUTAGE 1R11, UNIT 1 POOL BULK WATER/DISCHARGE FLOW TEMPERATURS
(During Cross-Tie Initiation)

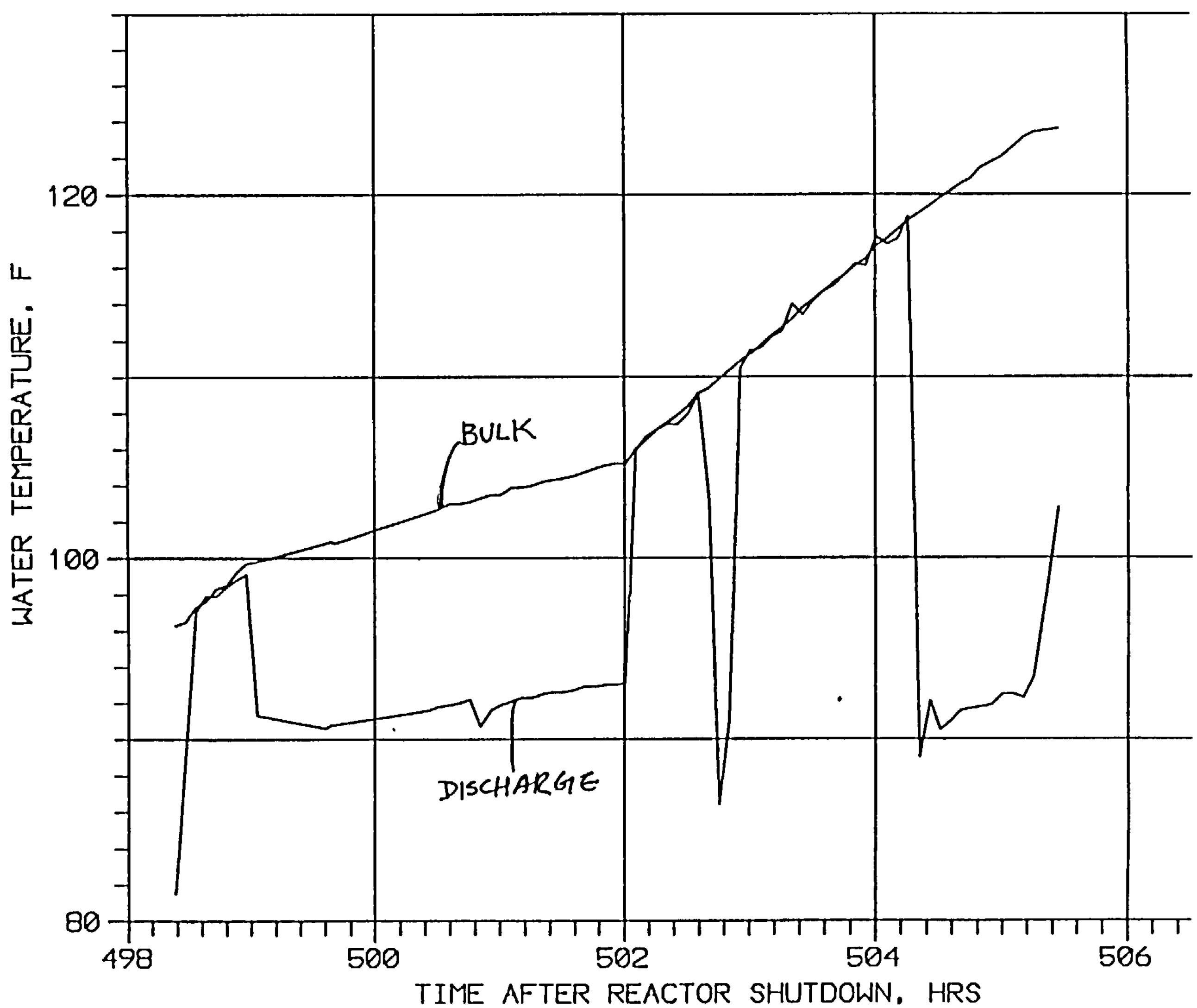

FIGURE 4.6

HOLTEC INTERNATIONAL

SALEM OUTAGE 1R11, UNIT 1 POOL WATER/UNIT 2 CCW INLET TEMPERATURES
(During Cross-tie)

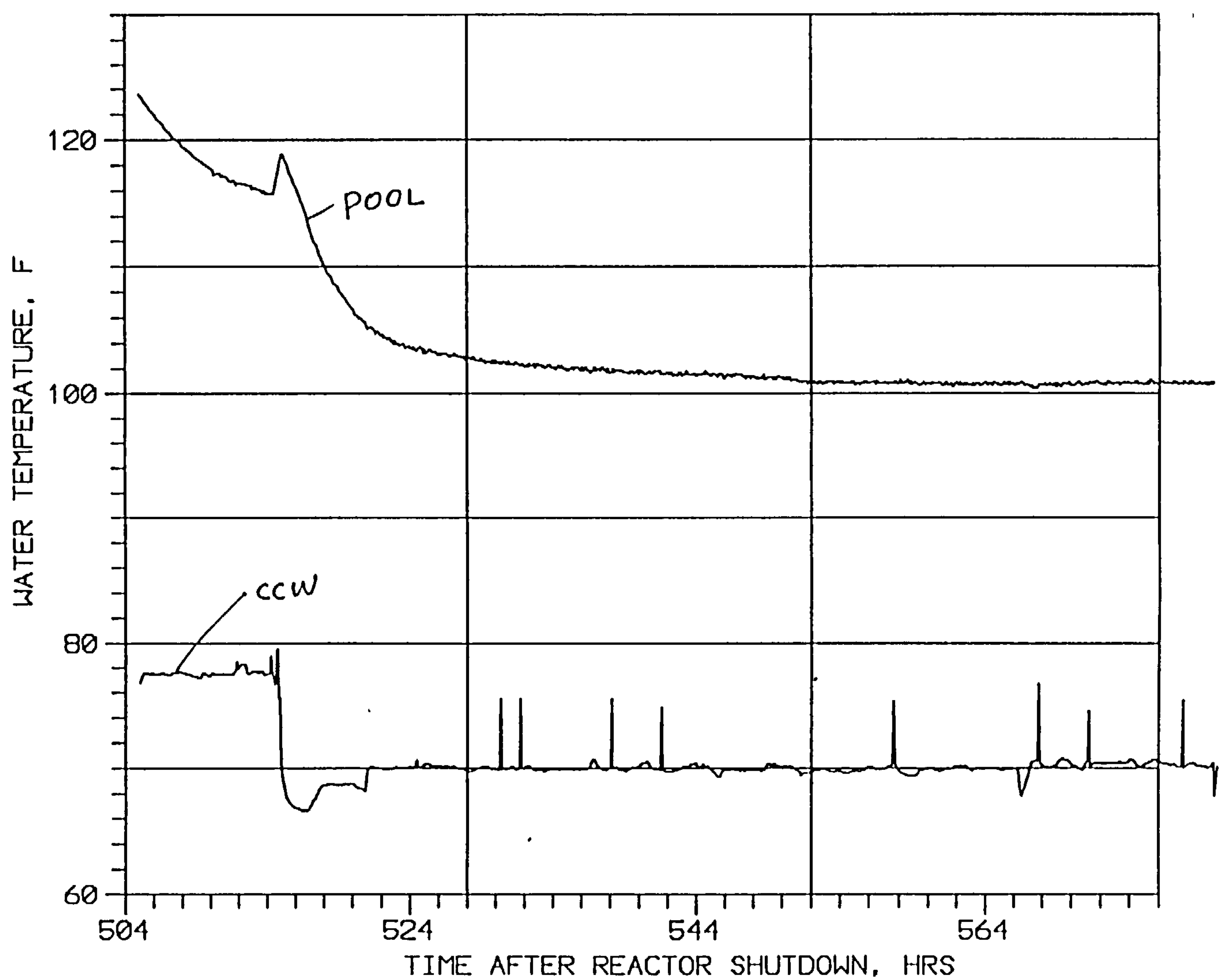

FIGURE 4.7

H-13

HOLTEC INTERNATIONAL

SALEM OUTAGE 1R11, UNIT 2 POOL BULK WATER TEMPERATURE

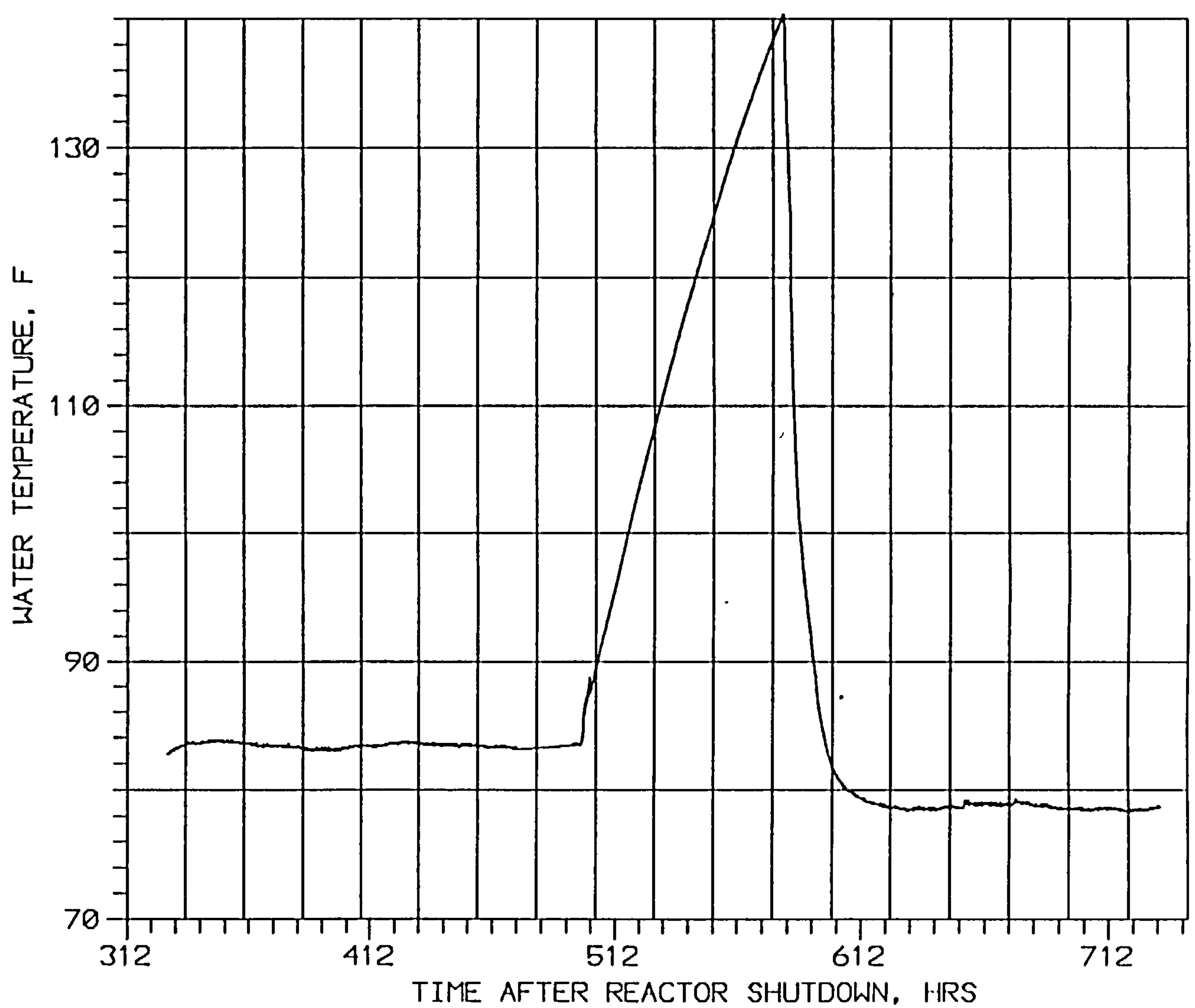

FIGURE 4.8

HOLTEC INTERNATIONAL

SALEM OUTAGE 1R11, UNIT 2 POOL BULK WATER TEMPERATURE
(During Cross-Tie Heating Up and After Cross-Tie Cooling Down)

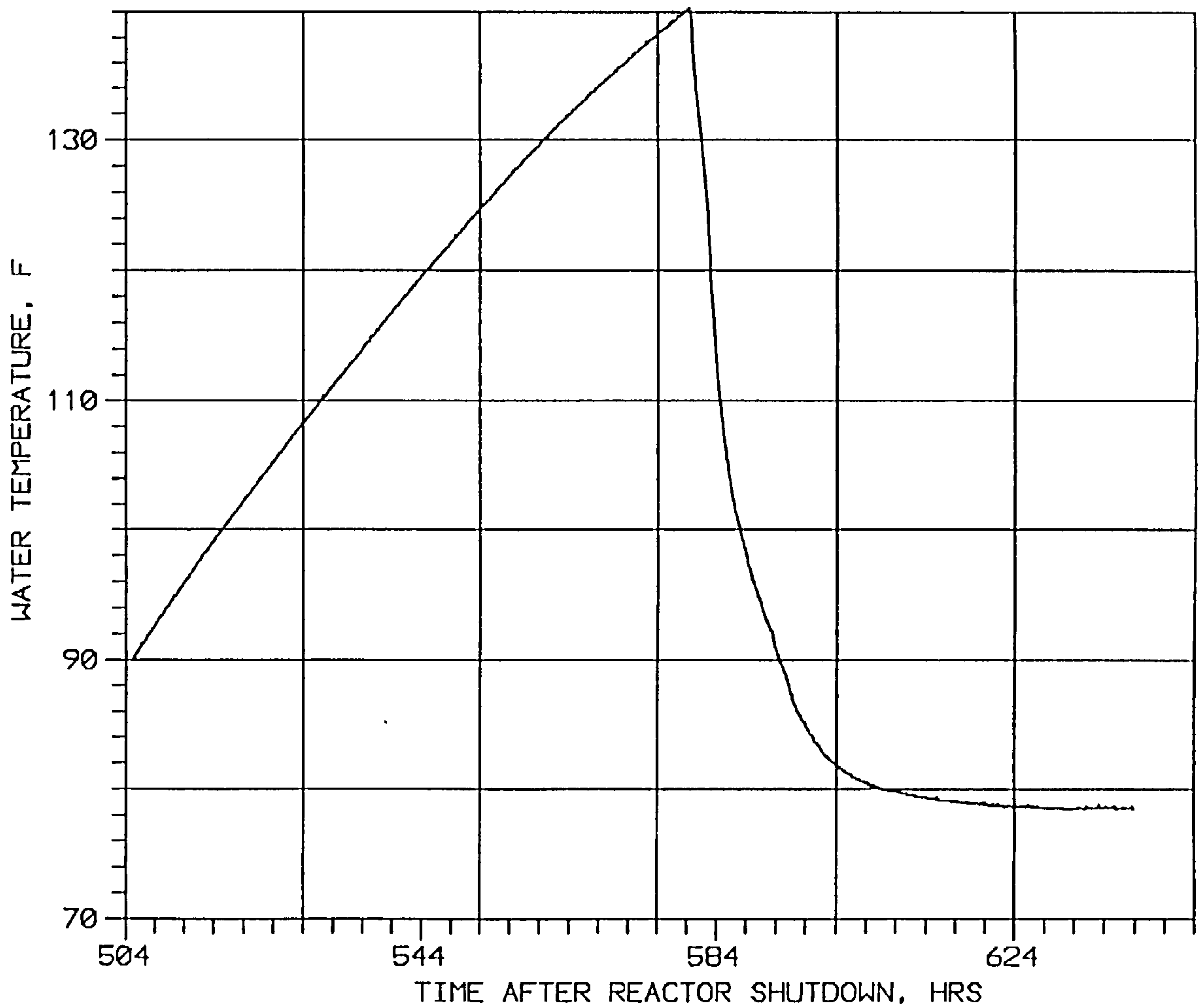

FIGURE 4.9

HOLTEC INTERNATIONAL

SALEM OUTAGE 1R11, UNIT 2 POOL BULK WATER/CCW TEMPERATURES
(Post Cross-Tie Cooling Down and Steady State)

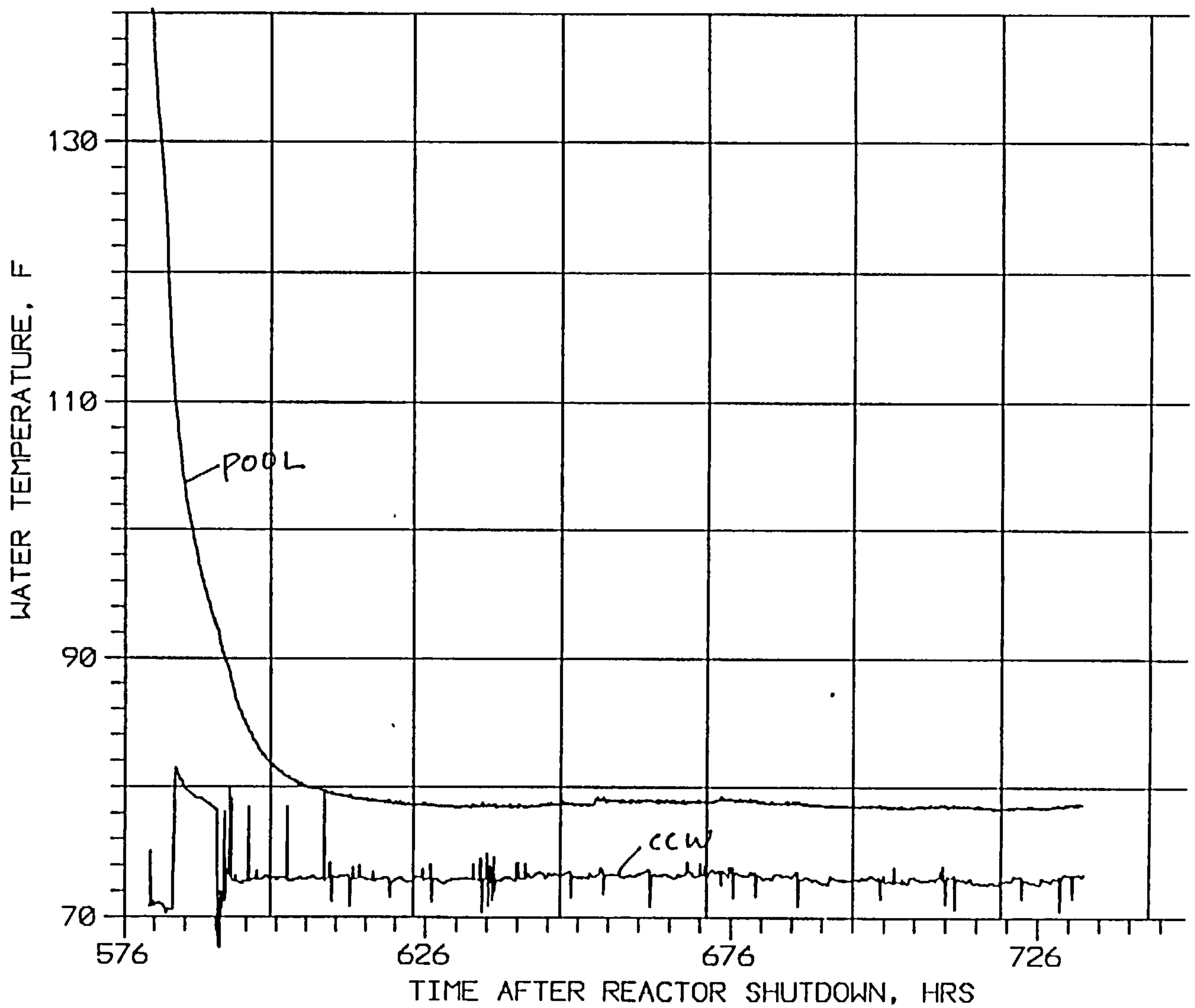

FIGURE 4.10

4-15

HOLTEC INTERNATIONAL

SALEM OUTAGE 1R11, UNIT 2 POOL BULK WATER/CCW TEMPERATURES
(STEADY STATE)

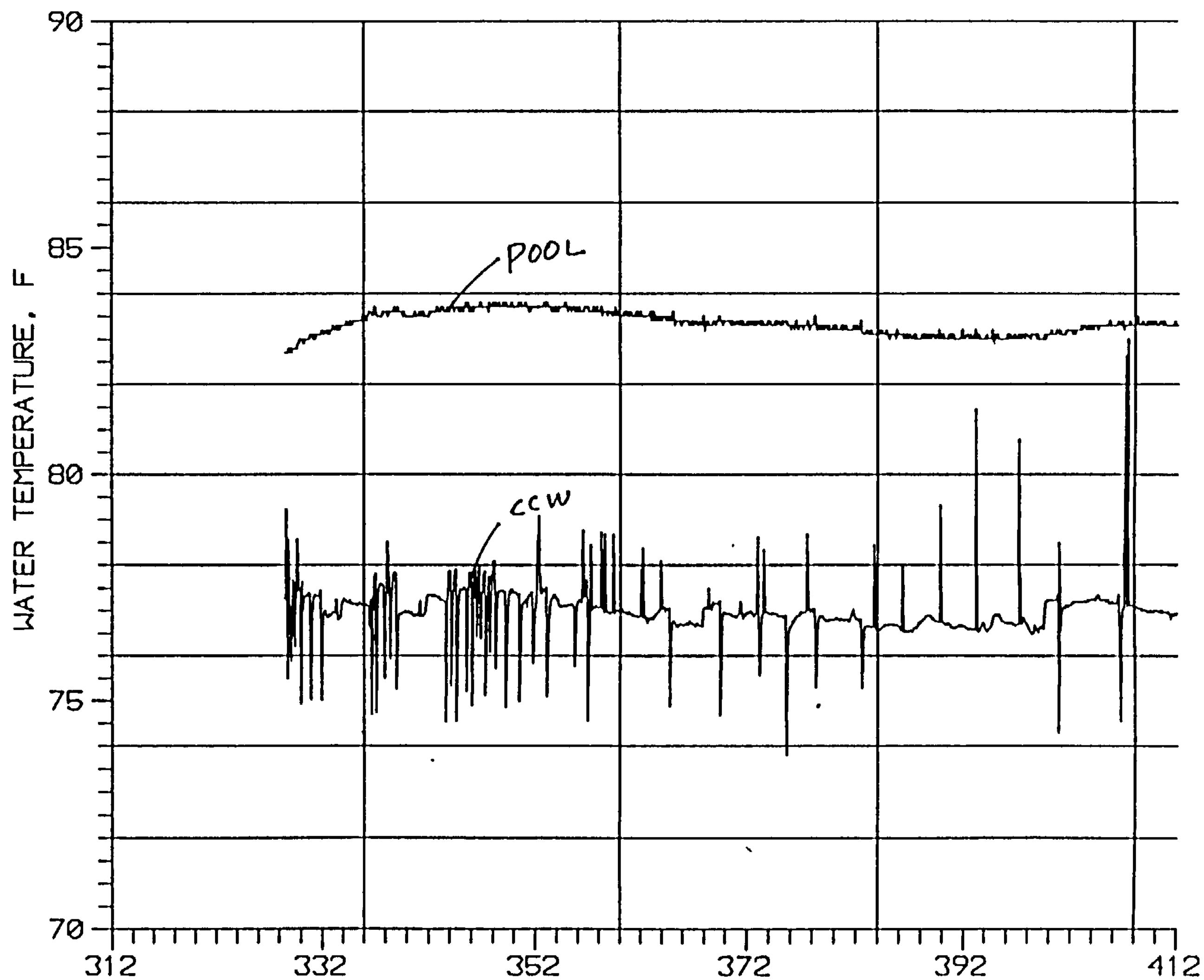

FIGURE 4.11

HOLTEC INTERNATIONAL

SALEM OUTAGE 1R11, UNIT 2 POOL BULK WATER/CCW TEMPERATURES (STEADY STATE)

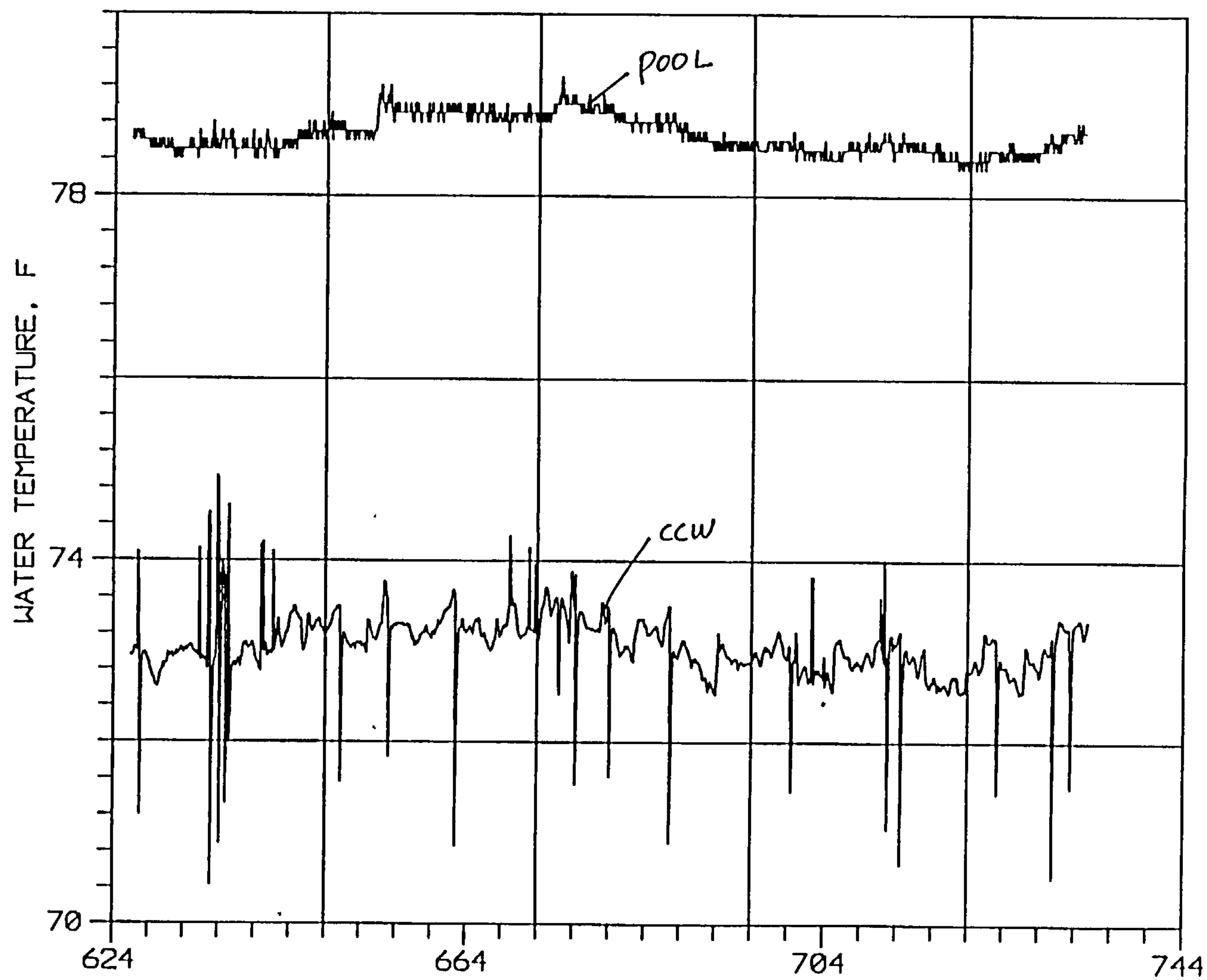

FIGURE 4.12

HOLTEC INTERNATIONAL

SALEM UNIT 1 FUEL HANDLING BUILDING RELATIVE HUMIDITY RATIO

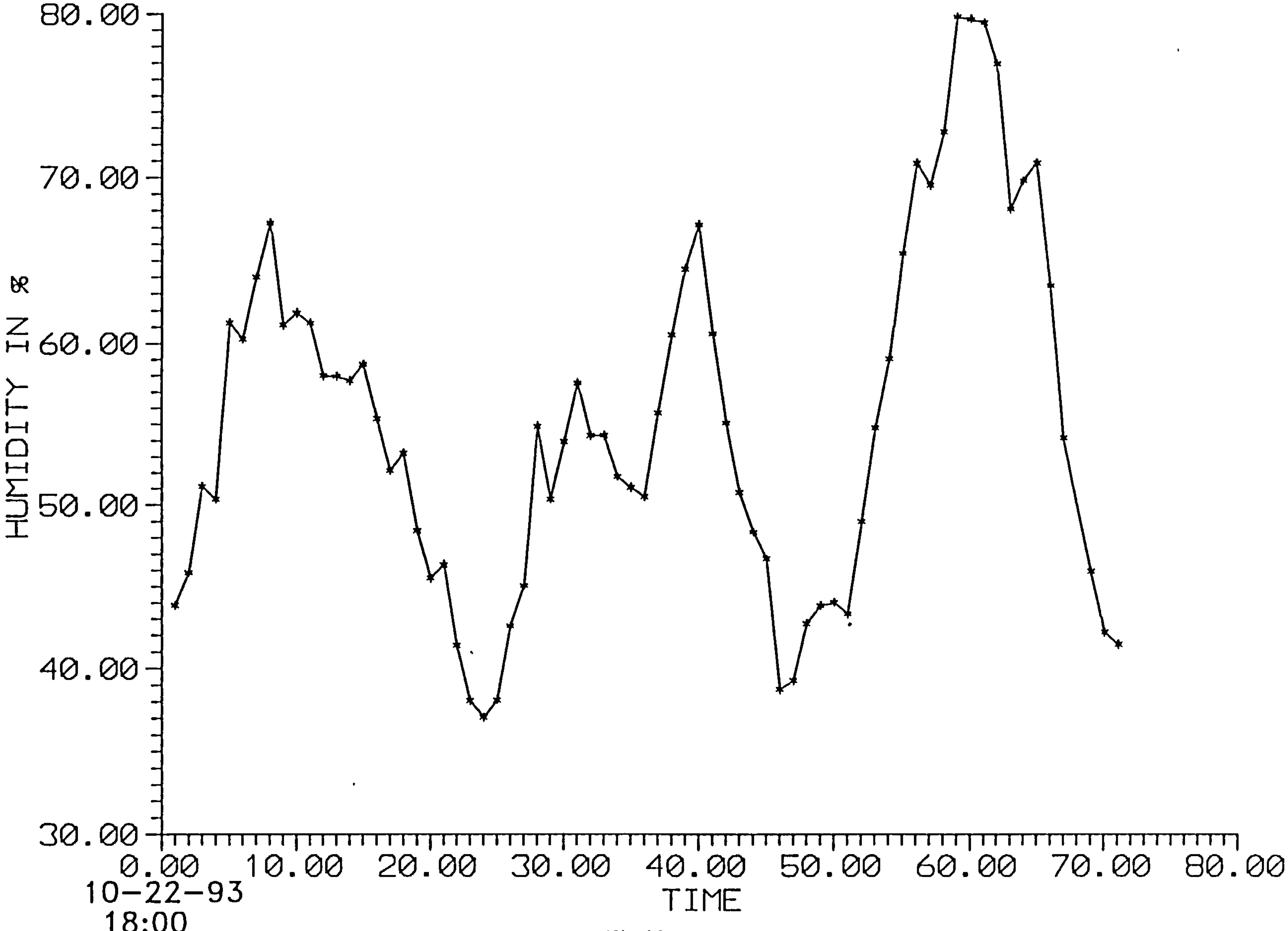

FIGURE 4.13

4-18

H-19

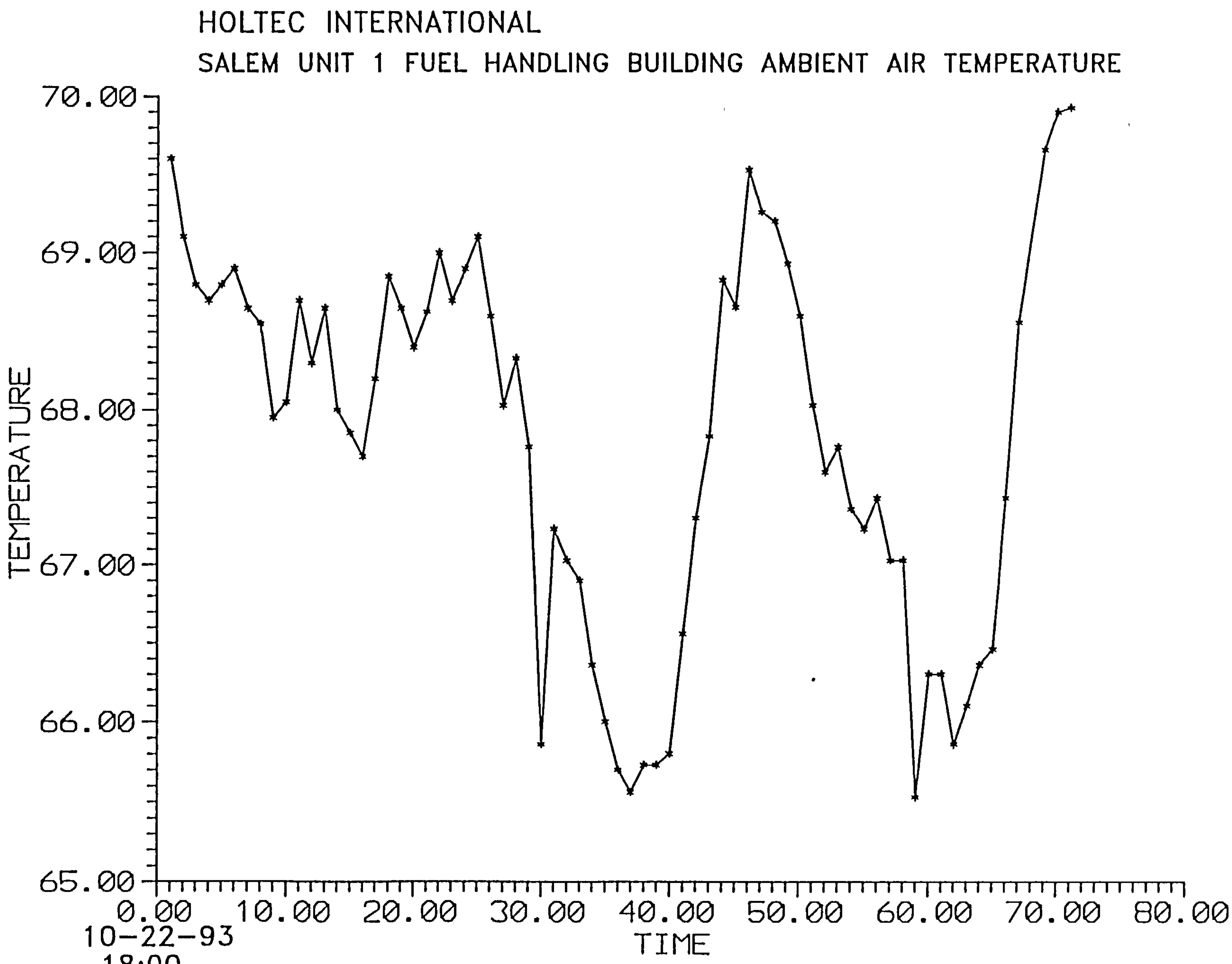

FIGURE 4.14

FIGURE 4.15

4-20

HOLTEC INTERNATIONAL

SALEM UNIT 2 FUEL HANDLING BUILDING AMBIENT AIR TEMPERATURE

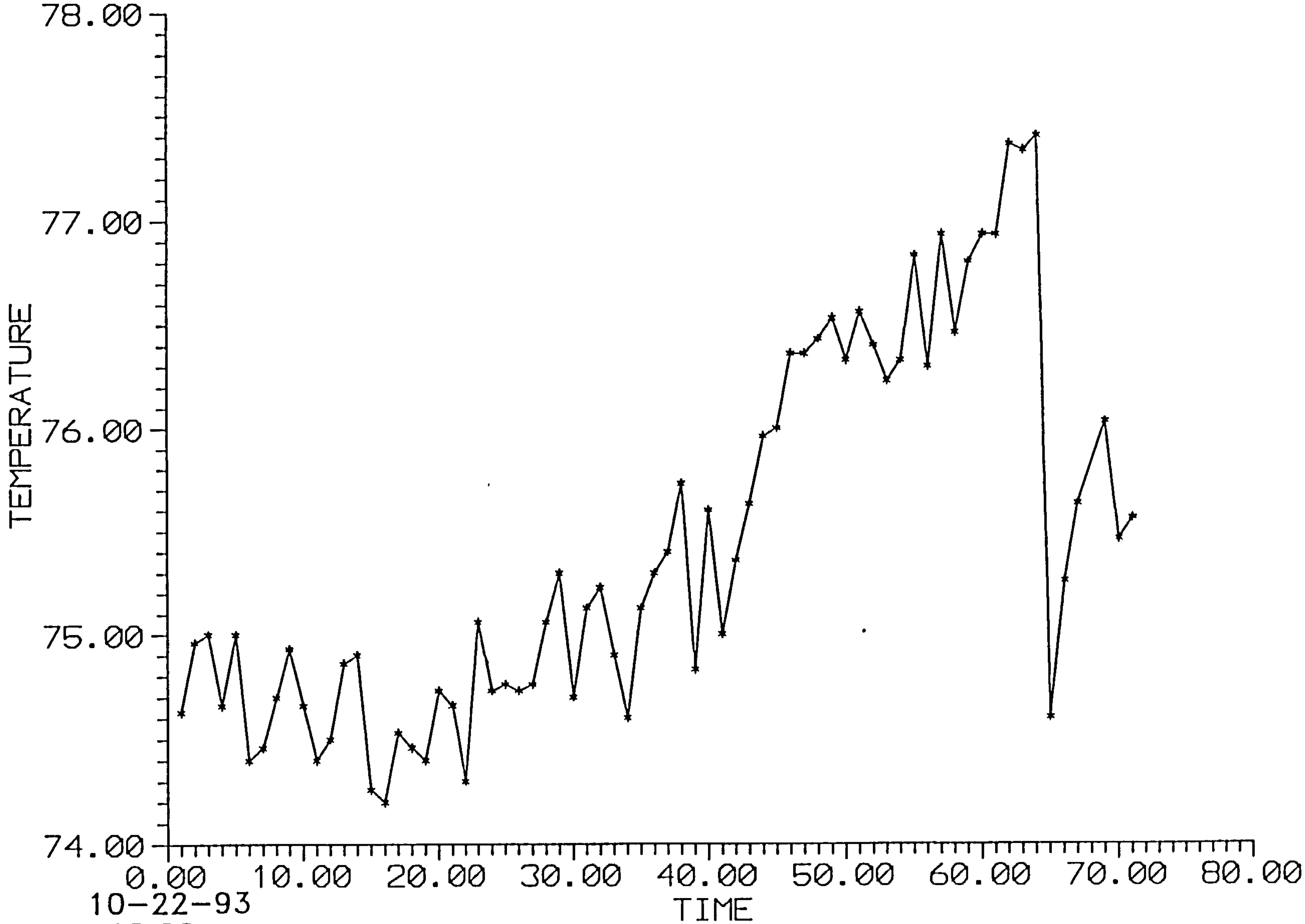

FIGURE 4.16

5.0 PROGRAM VALIDATION

5.1 Input Data

Net water volume

The 3-D schematic view of the Salem Units 1 and 2 pool is shown in Figure 4.1 and 4.3, respectively. The rectangular dimensions of the pool are 28.5' x 37' from Elevation 89'-6" (floor surface) to 105'-6" and 28.5' x 39' from 107'-6" to 130' (top of the pool). The normal water level is EL 128'-8" which is 38.17' from the floor. The transfer pool, which is connecting to the spent fuel pool through a 4' channel, is 16' x 28.5' from EL 130' to 89'-6" and 12' x 28.5' from EL 89'-6" to EL 84'-6".

Volume below water surface, V

$$
\begin{aligned}
V = {} & \left.\begin{array}{l}(28.5')\,(39')\,(128.67' - 107.5') \\ + (1/2)\,(107.5' - 105.5')\,(39' + 37')\,(28.5') \\ + (28.5')\,(37')\,(105.5' - 89.5')\end{array}\right\} \quad \text{spent fuel pool} \\
& \left.\begin{array}{l}+ (28.5')\,(16')\,(128.67' - 89.5') \\ + (28.5')\,(12')\,(89.5' - 84.5')\end{array}\right\} \quad \text{transfer pool} \\
= {} & 62{,}140 \text{ ft}^3
\end{aligned}
$$

Volume of Fuel Bundles, V_f

Consider 483 assemblies in the Unit 2 pool and 656 assemblies in the Unit 1 pool.

Single assembly wt: 1700 lbs (with control rods).

$$
\begin{aligned}
W_{f_2} &= 483 \times 1700 \\
&= 821{,}000 \ lbs
\end{aligned}
$$

$$W_{f_1} = 656 \times 1700 = 1{,}115{,}200 \ lbs$$

A fuel assembly consists of UO_2, Zinc, S/S

$$\rho_{UO_2} = 0.39 \ \#/in^3$$
$$\rho_{zinc} = 0.23 \ \#/in^3$$
$$\rho_{s/s} = 0.29 \#/in^3$$

Use $\rho = 0.23$ for maximum volume

$$V_{f_2} = \frac{W_{f_2}}{0.23} = \frac{821{,}000}{0.23}$$
$$= 3{,}570{,}000 \ in^3 = 2066 \ ft^3$$

$$V_{f_1} = \frac{W_{f_1}}{0.23} = \frac{1{,}115{,}200}{0.23}$$
$$= 4{,}849{,}000 \ in^3 = 2806 \ ft^3$$

<u>Volume of racks, V_r</u>

Rack wt. = 338 lbs/cell (Exxon Rack)

Total 1170 cells.

$$W_r = 1170 \ x \ 338 \ lbs$$
$$= 395{,}460$$

Stainless steel density, ρ_r = 0.29 lbs/in^3. Therefore

$$V_r = \frac{W_r}{\rho_r} = \frac{395{,}460}{0.29}$$
$$= 1{,}363{,}655 \ in^3 = 789 \ ft^3$$

$$V_{h_2} = V_r + V_{f_2} = 789 + 2066$$
$$= 2855 \ ft^3$$

$$V_{h_1} = V_r + V_{f_1} = 789 + 2806$$
$$= 3595 \ ft^3$$

Net water volume, V_n

Unit 2:

$$\begin{aligned} V_{n_2} &= V - V_{h_2} \\ &= 62148\ ft^3 - 2855\ ft^3 \\ &= 59285\ ft^3 \end{aligned}$$

Unit 1:

$$\begin{aligned} V_{n_1} &= V - V_{h_1} \\ &= 62148 - 3595 \\ &= 58{,}553\ ft^3 \end{aligned}$$

If one considers some credit for water in the pipe, storage tank, and the heat exchanger, use 59,000 ft^3 for Unit 1 pool verification and 60,000 ft^3 for Unit 2 pool verification.

Water surface area

Spent Fuel Pool

A_{S1} = 39' x 28.5' = 1111.5 ft^2

Transfer Pool

A_{S2} = 16' x 28.5' = 456 ft^2

Total

$A_S = A_{S1} + A_{S2}$ = 1567.5 ft_2

Heat Exchanger Performance Data

The heat exchanger performance data was referenced from Report HI-92942 (PSE&G Report S-C-SF-MDC-1240). The design basis parameters are summarized as follows:

Heat exchanger type:	One shell pass, 4-tube passes, U-tube shell-and-tube
SFP water flow rate, lb/hr:	1.14×10^6
CCW flow rate, lb/hr:	1.49×10^6
Film coefficient tubeside, Btu/ft^2,F:	2215.64
Film coefficient shellside, Btu/ft^2,F:	1500.64
Overall heat transfer surface area, ft^2:	2320
Tube outside diameter, in.:	0.75
Tube inside diameter, in.:	0.650
Tube wall thickness/conductivity, Btu/ft^2,F:	5.0 x 54E-4
Fouling factor shellside, Btu/ft^2-F	0.0002
Fouling factor tubeside, Btu/ft^2-F	0.0002

The fouling factors were calibrated by the test on the Unit 2 heat exchangers.

SALEM UNIT 1 SPENT FUEL POOL
SPENT FUEL INVENTORY BURNUP DATA (PROVIDED BY PSE&G)

CYCLE	DISCHARGE DATE	BATCH	#FAs	U-kg	MWD/MTU	R-POWER MW(t)
1	04,03,79	1	28	461.0	17000	3338
1	04,03,79	2	04	461.0	17500	3338
1	04,03,79	3	06	461.0	12000	3338
2	09,19,80	1	36	461.0	24100	3338
2	09,19,80	2	28	461.0	26100	3338
3	01,01,82	1	32	461.0	34100	3338
3	01,01,82	2	24	461.0	32400	3338
4	10,15,82	1	33	461.0	36200	3338
4	10,15,82	1	01	461.0	23600	3338
5	02,20,84	1	01	461.0	26800	3338
5	02,20,84	2	39	461.0	32500	3338
5	02,20,84	3	28	461.0	26700	3338
5	02,20,84	4	03	461.0	26600	3338
5	02,20,84	5	01	461.0	17200	3338
5	02,20,84	6	01	461.0	12200	3338
6	03,21,86	1	09	461.0	30300	3338
6	03,21,86	2	04	461.0	34500	3338
6	03,21,86	3	01	461.0	41900	3338
6	03,21,86	4	25	461.0	33500	3338
6	03,21,86	5	28	461.0	31100	3338
6	03,21,86	6	02	461.0	36900	3338
7	10,02,87	1	01	461.0	43600	3411
7	10,02,87	2	09	461.0	36400	3411
7	10,02,87	3	08	461.0	40500	3411
7	10,02,87	4	41	461.0	36600	3411
7	10,02,87	5	11	461.0	36900	3411
8	03,23,89	1	08	461.0	39800	3411
8	03,23,89	2	04	461.0	37900	3411
8	03,23,89	3	01	461.0	40600	3411
8	03,23,89	4	04	461.0	34900	3411
8	03,23,89	5	47	461.0	35000	3411
8	03,23,89	6	08	461.0	37800	3411
8	03,23,89	7	02	461.0	16300	3411
9	02,09,91	1	07	461.0	31500	3411
9	02,09,91	2	01	461.0	31800	3411
9	02,09,91	3	04	461.0	37000	3411
9	02,09,91	4	29	461.0	42700	3411
9	02,09,91	5	41	461.0	33500	3411
9	02,09,91	6	01	461.0	39300	3411
9	02,09,91	7	02	461.0	19500	3411

10	04,03,92	1	08	461.0	26600	3411
10	04,03,92	2	07	461.0	33200	3411
10	04,03,92	3	04	461.0	36600	3411
10	04,03,92	4	02	461.0	41100	3411
10	04,03,92	5	08	461.0	39500	3411
10	04,03,92	6	15	461.0	40100	3411
10	04,03,92	7	25	461.0	39300	3411
10	04,03,92	8	01	461.0	25700	3411
10	04,03,92	9	08	461.0	38600	3411
10	04,03,92	10	08	461.0	48100	3411
10	04,03,92	11	01	461.0	43700	3411
10	04,03,92	12	01	461.0	31500	3411
10	04,03,92	13	01	461.0	48700	3411
10	04,03,92	14	01	461.0	49400	3411
10	04,03,92	15	01	461.0	43600	3411
10	04,03,92	16	01	461.0	42200	3411
10	04,03,92	17	01	461.0	48200	3411

SALEM UNIT 2 SPENT FUEL POOL
SPENT FUEL INVENTORY BURNUP DATA (PROVIDED BY PSE&G)

CYCLE	DISCHARGE DATE	BATCH	#FAs	U-kg	MWD/MTU	R-POWER MW(t)
1	01,21,83	1	56	461.0	18400	3411
1	01,21,83	2	12	461.0	19700	3411
2	10,04,84	1	09	461.0	20700	3411
2	10,04,84	2	52	461.0	23900	3411
2	10,04,84	3	07	461.0	21600	3411
3	10,02,86	1	53	461.0	33400	3411
3	10,02,86	2	04	461.0	21600	3411
4	08,31,88	1	02	461.0	32200	3411
4	08,31,88	2	30	461.0	37000	3411
4	08,31,88	3	42	461.0	37400	3411
4	08,31,88	4	03	461.0	38500	3411
5	03,31,90	1	09	461.0	36000	3411
5	03,31,90	2	08	461.0	29700	3411
5	03,31,90	3	12	461.0	41500	3411
5	03,31,90	4	01	461.0	25300	3411
5	03,31,90	5	45	461.0	36500	3411
6	11,09,91	1	33	461.0	42400	3411
6	11,09,91	2	28	461.0	36400	3411
6	11,09,91	3	08	461.0	32300	3411
7	03,16,93	1	08	461.0	34800	3411
7	03,16,93	2	08	461.0	39600	3411
7	03,16,93	3	01	461.0	29300	3411
7	03,16,93	4	01	461.0	43100	3411
7	03,16,93	5	08	461.0	39900	3411
7	03,16,93	6	39	461.0	36400	3411
7	03,16,93	7	04	461.0	46800	3411

5.2 Program Verification

Input from Measurement:

Verification Case 1 - Unit 2 Steady State Before Cross-Tie

CCW inlet temperature, °F:	77
CCW flow rate, gpm:	2100
SFP flow, gpm:	2040
Time after reactor shutdown, hr.:	336-408 (about 15-17 days after reactor shutdown)
Ambient air temperature, °F:	74
Relative humidity ratio, %:	33

Verification Case 2 - Unit 2 Steady State After Cross-Tie

CCW inlet temperature, °:	73.2
CCW flow rate, gpm:	3050
SFP flow, gpm:	2040
Time after shutdown, hr.:	624-744
Ambient air temperature, °F:	75.5
Relative humidity ratio, %:	50

Verification Case 3 - Unit 2 Pool Heating Up During 1R11 Cross-Tie

Before HX isolation:

CCW inlet temperature, °F:	77
CCW flow rate, gpm:	2100
SFP flow rate, gpm:	2040
TARS* to start exchanger isolation, hrs.:	496
Temperature limit, °F:	140.3
Ambient air temperature, °F:	75.5
Relative humidity ratio, %:	60

Verification Case 4 - Unit 2 Pool Cooling Down After 1R11 Cross-Tie

CCW inlet temperature, °F:	73
CCW flow rate, gpm:	3050
SFP flow rate, gpm:	2040
TARS to re-initiate exchanger, hrs.:	580.27
Initial temperature, °F:	140.3
Ambient temperature, °F:	75
Relative humidity ratio, %:	60

* TARS = Time After Reactor Shutdown

Verification Case 5 - Unit 1 Pool Cooled by Unit 2 Exchanger During 1R11 Outage

CCW inlet temperature, °F:	77.5
CCW flow rate, gpm:	2100
SFP flow rate, gpm:	2460
TARS to start cooling, hrs.:	505
Initial bulk water temperature, °F:	123.6
TARS to end, hrs.:	514.6
Average burnup of 61 assemblies, MWD/MTU	41,300
Average burnup of 64 assemblies, MWD/MTU	27,760
Average burnup of 68 assemblies, MWD/MTU	15,240
Capacity factor:	0.9
Ambient air temperature, °F:	68.5
Relative humidity, %:	55

Verification Case 6 - Unit 1 Pool Cooled by Unit 2 Exchanger During 1R11 Outage

CCW inlet temperature, °F:	70
CCW flow rate, gpm:	3050
SFP flow rate, gpm:	2460
TARS to start cooling, hrs.:	515.13
Initial bulk water temperature, °F:	118.9
TARS to end, hrs.:	579.7
Average burnup of 61 assemblies, MWD/MTU	41,300
Average burnup of 64 assemblies, MWD/MTU	27,760
Average burnup of 68 assemblies, MWD/MTU	15,240
Capacity factor:	0.9
Ambient air temperature, °F:	67.5
Relative humidity, %:	55

For each verification case, the calculated temperature is plotted with the measurement (see Figures 5.1 to 5.6). It is shown that the maximum mean error in all cases is less than 1.0% of the measured values, which is well within the experimental error.

Hard copy of all cases of runs are attached.

HOLTEC INTERNATIONAL

PROGRAM CROSSTIE VERIFICATION CASE 1
UNIT 2 POOL STEADY STATE CONDITION BEFORE 1R11 CROSS-TIE

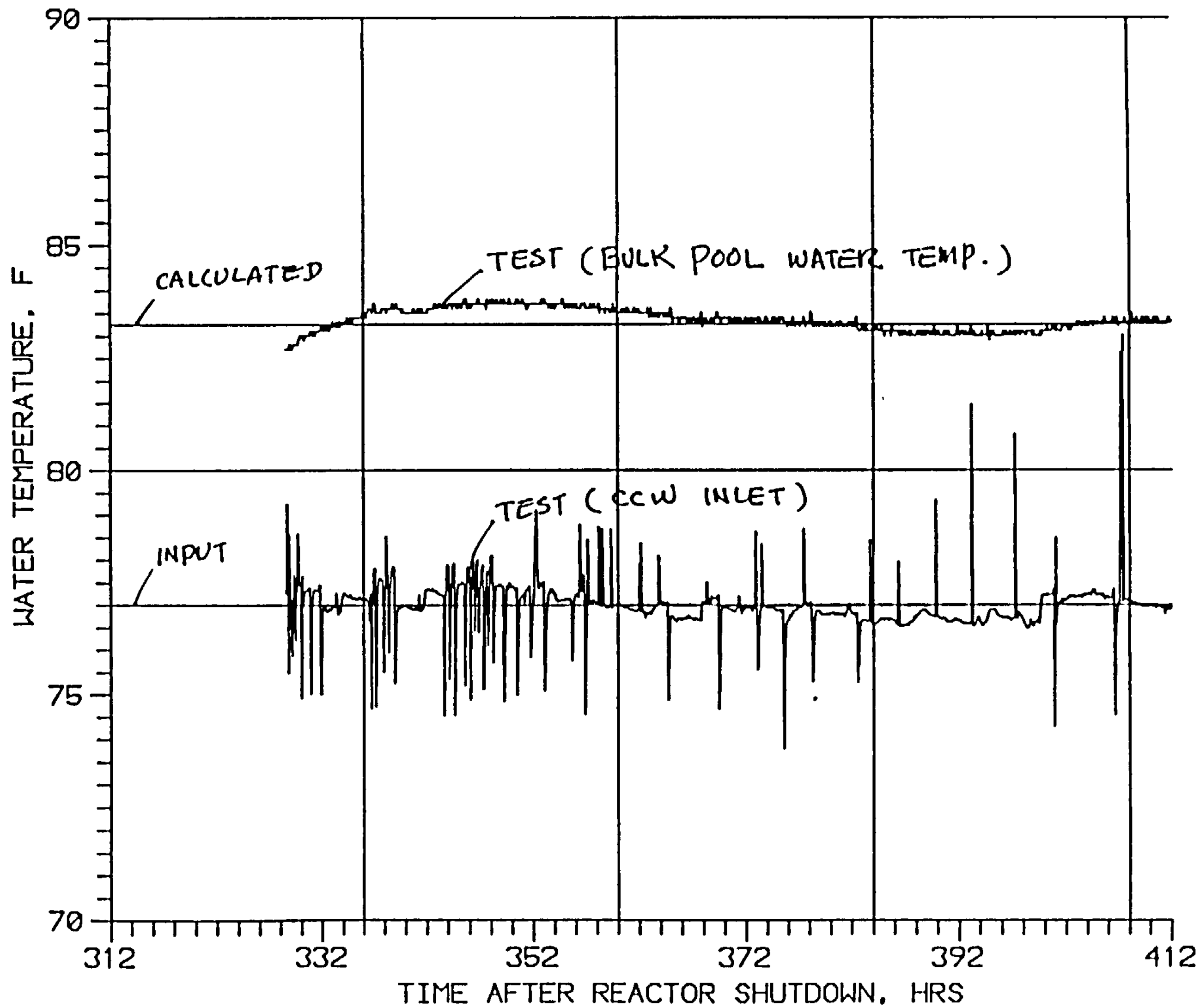

FIGURE 5.1

HOLTEC INTERNATIONAL

PROGRAM CROSSTIE VERIFICATION CASE 2
UNIT 2 POOL STEADY STATE CONDITION AFTER 1R11 CROSS-TIE

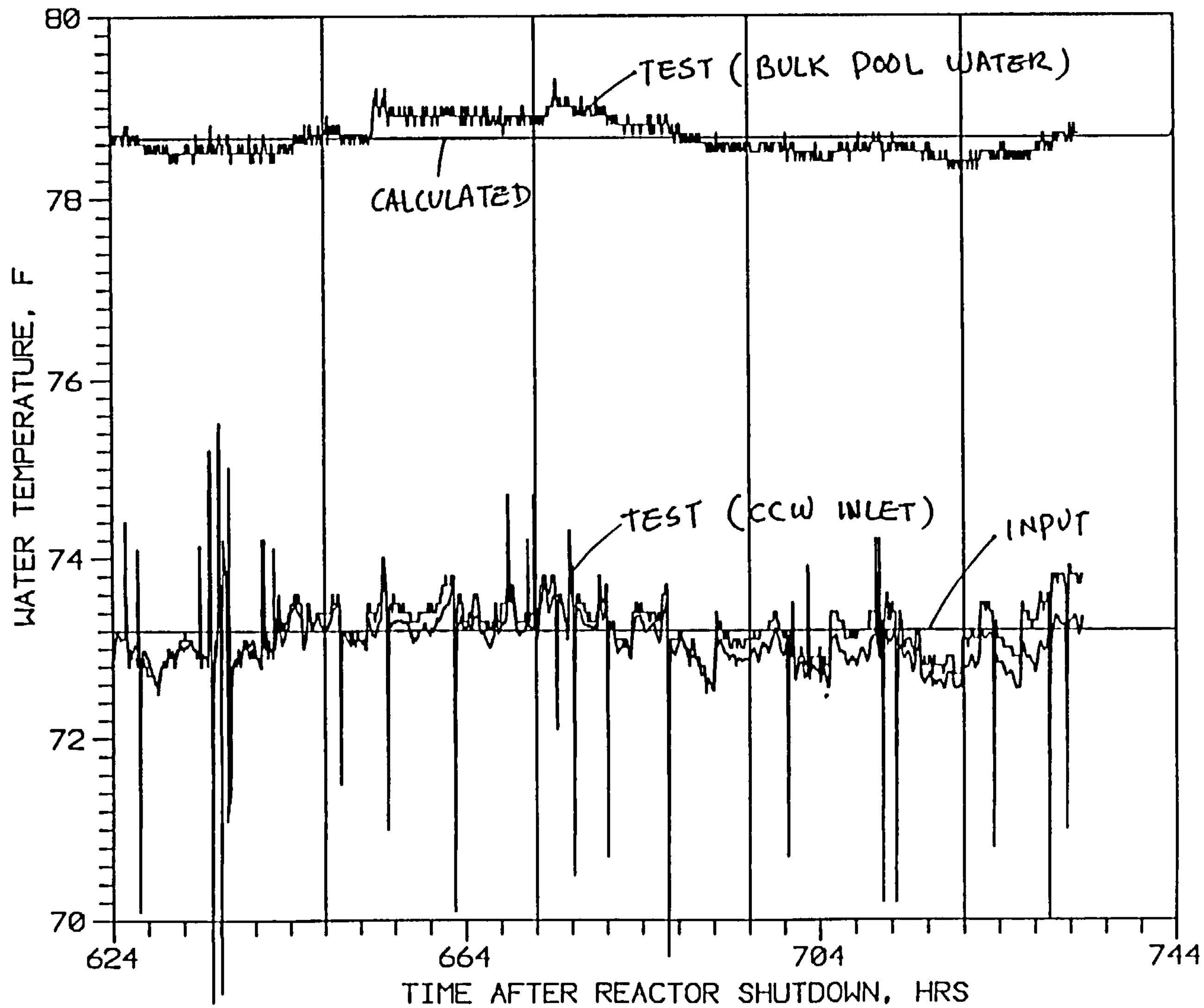

FIGURE 5.2

HOLTEC INTERNATIONAL

PROGRAM CROSSTIE VERIFICATION CASE 3
UNIT 2 POOL HEATING UP DURING 1R11 CROSS-TIE

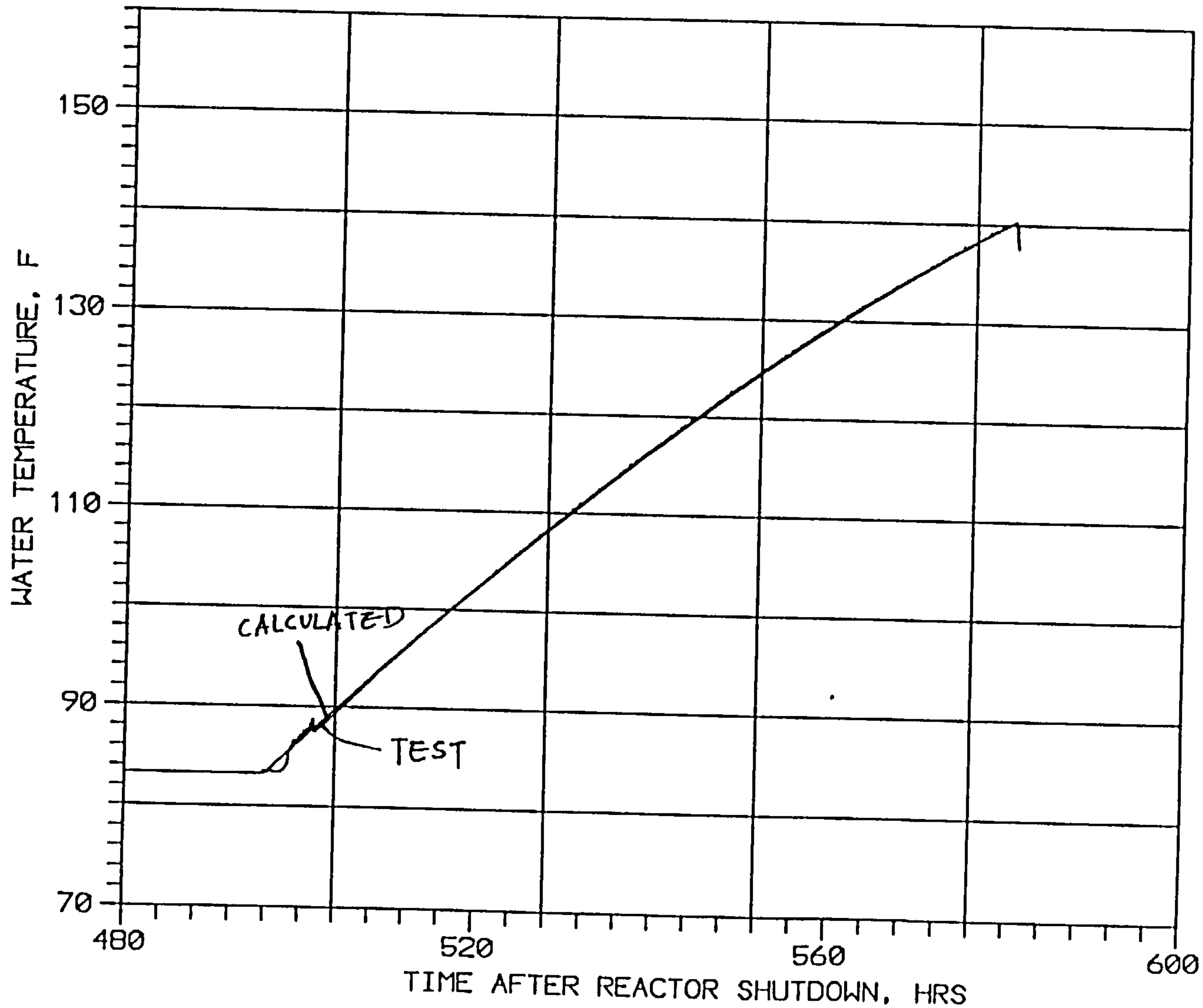

FIGURE 5.3

HOLTEC INTERNATIONAL

PROGRAM CROSSTIE VERIFICATION CASE 4
UNIT 2 POOL COOLING DOWN DURING 1R11 CROSS-TIE *

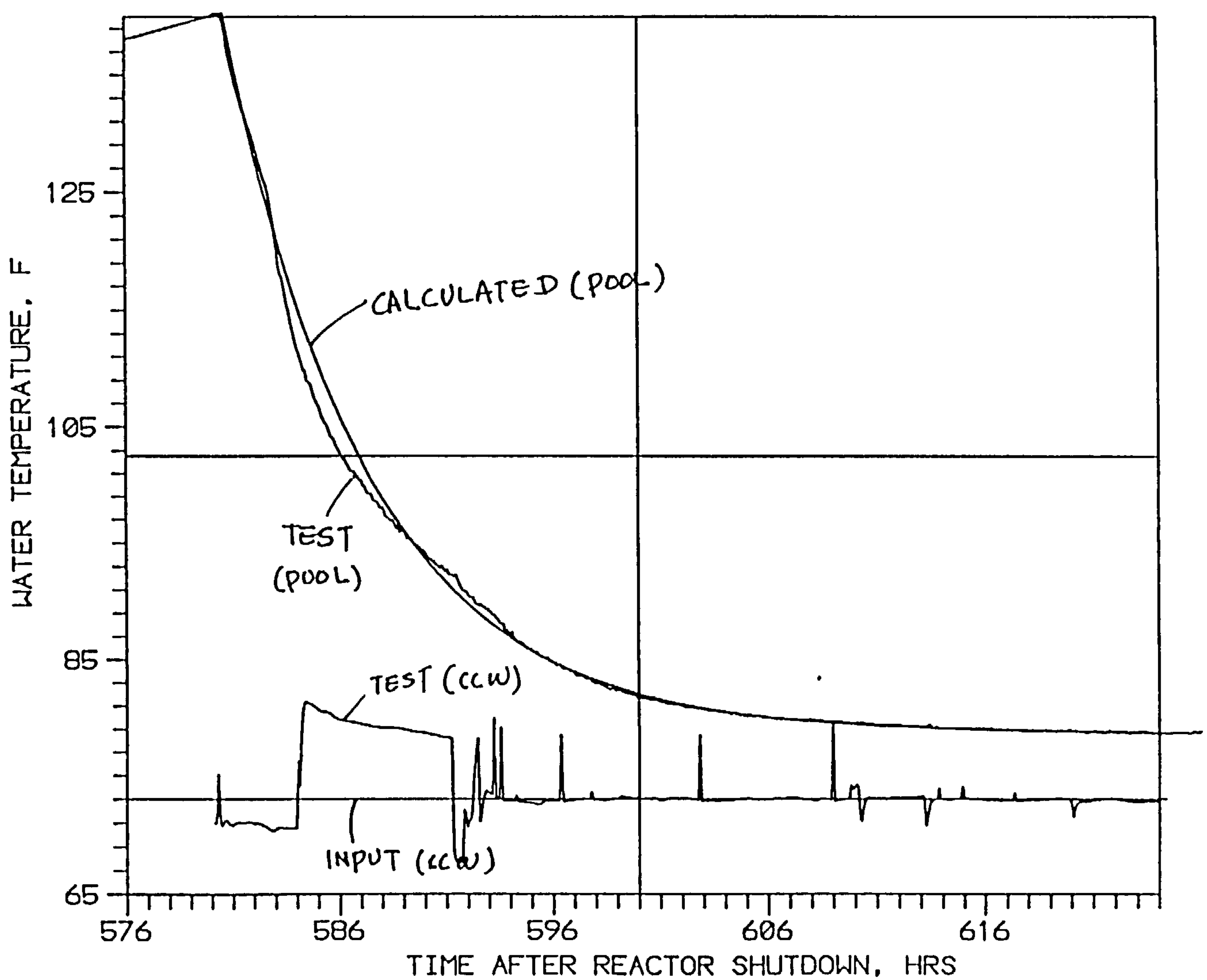

FIGURE 5.4

* "CROSS-TIE" IS DEFINED BY HOLTEC AS THE PERIOD OF TIME FOR THE TEST, INCLUDING CYCLING BETWEEN THE TWO POOLS FOR A UNIT 1 OUTAGE. UNIT 2 POOL COOLING IS DONE BY UNIT 2 SFHX (IP, W/O CROSS-TIE); FOR 1R11, UNIT 2 POOL COOLING WAS ACTUALLY AFTER ALL CROSS-TIE ACTIVITIES WERE COMPLETED K. Kniep 5/12/94 per telecon

HOLTEC INTERNATIONAL

PROGRAM CROSSTIE VERIFICATION CASES 5 AND 6
UNIT 1 POOL TEMPERATURE DURING 1R11 CROSSTIE

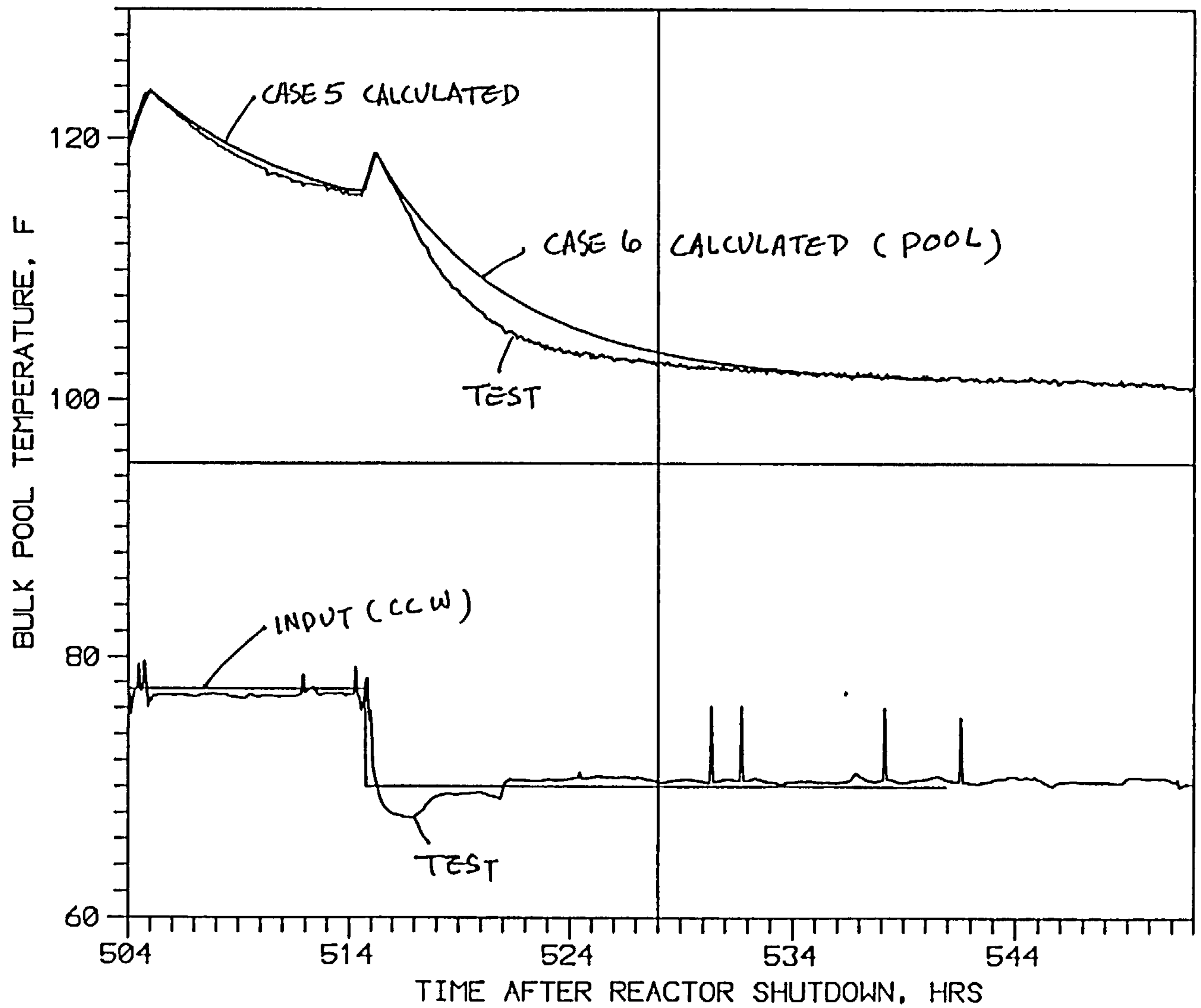

FIGURE 5.5

INPUT DATA FILES FOR ALL VERIFICATION CASES

CASE1.DAT

```
 PROGRAM CROSSTIE VERIFICATION CASE 1
10,02,93
1
2100, 2040, 60000
0,0,0,240.,60.
3411.,1.0,0.,0.,0.,461.0
74., 0.33
```

CASE2.DAT

```
 PROGRAM CROSSTIE VERIFICATION CASE 2
10,02,93
1
3050, 2040, 60000
0,0,0,240.,60.
3411.,1.0,0.,0.,0.,461.0
75.5, 0.50
```

CASE3.DAT

```
 PROGRAM CROSSTIE VERIFICATION CASE 3
10,02,93
1
2100, 2040, 60000
0,0,0,240.,60.
3411.,1.0,0.,0.,0.,461.0
75.5, 0.60
```

CASE4.DAT

```
 PROGRAM CROSSTIE VERIFICATION CASE 4
10,02,93
1
3050, 2040, 60000
0,0,0,240.,60.
3411.,1.0,0.,0.,0.,461.0
75., 0.60
```

CASE5.DAT

```
PROGRAM CROSSTIE VERIFICATION CASE 5
10,02,93
1
2100, 2460, 59000
61,64,68,240.,60.
3411.,0.9,41300.,27760.,15240.,461.0
68.5, 0.55
```

CASE6.DAT

```
 PROGRAM CROSSTIE VERIFICATION CASE 6
10,02,93
1
3050, 2460, 59000
61,64,68,240.,60.
3411.,0.9,41300.,27760.,15240.,461.0
67.5, 0.55
```

OUTPUT FILES FOR ALL VERIFICATION CASES

FILE: CASE1.TEM

*****HOLTEC INTERNATIONAL*****

********COMPUTER CODE CROSSTIE********

$Revision: 1.0 $

$Date: 17 Dec 1993 23:30:18 $

$Logfile: C:/RACKHEAT/CONTROL/CROSSTIE.FOV $

THIS PROGRAM WAS VERIFIED BY THE TEST
PERFORMED DURING SALEM 1R11 OUTAGE, OCTOBER 1993

DESCRIPTION OF YOUR JOB
PROGRAM CROSSTIE VERIFICATION CASE 1

```
 REACTOR SHUTDOWN DATE:
   10   2  93
 OUTAGE UNIT, TIME TO START CROSS-TIE (HR), AND TEMP   LIMIT(F)
   1       412.00       140.30
  CCW FLOW(GPM),SFP FLOW(GPM),CCW TEMP(F),& NET WATER  VOLUME (ft^3)
      2100.00      2040.00        77.00    60000.00
 N1,N2,N3,Tao(HR),TaoS(HR)
     0     0     0     240.00       60.00
 RP(MW), CF, BP1(MWD/MTU), BP2, BP3, UW(Kg)
 3411.0   1.0         .00          .00         .00 461.00
 FH BUILDING AMBIENT TEMP(F), RELATIVE HUMIDITY(%)*
        74.00          .33
 THE ENDING TIME(HR)
       412.00
```

Heat Exchanger Temperature effectiveness p= .4489

	UNIT 1				UNIT 2			
	(POOL)	(HT-TO-HX)	(HT-LOSS)		(POOL)	(HT-TO-HX)	(HT-LOSS)	
TIME	T1	Q1	Qls1	HX1+	T2	Q2	Qls2	HX2+
(HR)	(F)	(BTU/HR)	(BTU/HR)		(F)	(BTU/HR)	(BTU/HR)	
.00	81.7	.2196E+07	.83E+05	1	83.2	.2912E+07	.96E+05	1
411.50	81.7	.2196E+07	.83E+05	1	83.2	.2912E+07	.96E+05	0

* NOTE THAT RH ACTUALLY PRINTS OUT DECIMAL VALUE (TYP OF ALL CASES) THEREFORE, FOR THIS CASE, RH = .33 = 33% K. King per Telecon 5/12/94

\+ "1" = HX IN SERVICE (TYP) K. King per telecon 5/12/94
"0" = HX OUT OF SERVICE (TYP)

FILE: CASE2.TEM

```
                    *****HOLTEC INTERNATIONAL*****

                 ********COMPUTER CODE CROSSTIE********

$Revision:   1.0  $

$Date:   17 Dec 1993 23:30:18  $

$Logfile:   C:/RACKHEAT/CONTROL/CROSSTIE.FOV  $


  THIS PROGRAM WAS VERIFIED BY THE TEST
  PERFORMED DURING SALEM 1R11 OUTAGE, OCTOBER 1993


 DESCRIPTION OF YOUR JOB
  PROGRAM CROSSTIE VERIFICATION CASE 2


 REACTOR SHUTDOWN DATE:
   10   2  93
 OUTAGE UNIT, TIME TO START CROSS-TIE (HR), AND TEMP   LIMIT(F)
   1      744.00      140.30
  CCW FLOW(GPM),SFP FLOW(GPM),CCW TEMP(F),& NET WATER  VOLUME (ft^3)
      3050.00     2040.00        73.20     60000.00
 N1,N2,N3,Tao(HR),TaoS(HR)
     0    0    0   240.00      60.00
 RP(MW), CF, BP1(MWD/MTU), BP2, BP3, UW(Kg)
 3411.0   1.0        .00         .00         .00 461.00
 FH BUILDING AMBIENT TEMP(F), RELATIVE HUMIDITY(%)
       75.50        .50
 THE ENDING TIME(HR)
       744.00

 Heat Exchanger Temperature effectiveness p= .3473
```

	UNIT 1				UNIT 2			
	(POOL)	(HT-TO-HX)	(HT-LOSS)		(POOL)	(HT-TO-HX)	(HT-LOSS)	
TIME	T1	Q1	Qls1	HX1	T2	Q2	Qls2	HX2
(HR)	(F)	(BTU/HR)	(BTU/HR)		(F)	(BTU/HR)	(BTU/HR)	
.00	77.4	.2219E+07	.29E+05	1	78.7	.2860E+07	.39E+05	1
743.50	77.4	.2219E+07	.29E+05	1	78.7	.2860E+07	.39E+05	0

FILE: CASE3.TEM

*****HOLTEC INTERNATIONAL*****

********COMPUTER CODE CROSSTIE********

```
$Revision:   1.0  $

$Date:   17 Dec 1993 23:30:18   $

$Logfile:   C:/RACKHEAT/CONTROL/CROSSTIE.FOV  $


  THIS PROGRAM WAS VERIFIED BY THE TEST
  PERFORMED DURING SALEM 1R11 OUTAGE, OCTOBER 1993


 DESCRIPTION OF YOUR JOB
  PROGRAM CROSSTIE VERIFICATION CASE 3


 REACTOR SHUTDOWN DATE:
   10   2  93
 OUTAGE UNIT, TIME TO START CROSS-TIE (HR), AND TEMP   LIMIT(F)
   1      496.00      140.30
  CCW FLOW(GPM),SFP FLOW(GPM),CCW TEMP(F),& NET WATER  VOLUME (ft^3)
      2100.00      2040.00       77.00    60000.00
 N1,N2,N3,Tao(HR),TaoS(HR)
     0    0    0   240.00      60.00
 RP(MW), CF, BP1(MWD/MTU), BP2, BP3, UW(Kg)
 3411.0   1.0       .00        .00        .00 461.00
 FH BUILDING AMBIENT TEMP(F), RELATIVE HUMIDITY(%)
       75.50         .60
 THE ENDING TIME(HR)
      600.00

 Heat Exchanger Temperature effectiveness p= .4489

             UNIT 1                          UNIT 2
          (POOL) (HT-TO-HX) (HT-LOSS)     (POOL)(HT-TO-HX)  (HT-LOSS)
  TIME     T1        Q1        Qls1    HX1  T2       Q2        Qls2    HX2
  (HR)     (F)    (BTU/HR)   (BTU/HR)       (F)   (BTU/HR)   (BTU/HR)
    .00   81.8  .2215E+07   .57E+05    1  83.2  .2911E+07   .68E+05    1
 495.50   81.8  .2215E+07   .57E+05    1  83.2  .2911E+07   .68E+05    0
 580.31   81.8  .2215E+07   .57E+05    0 140.3  .1720E+07   .13E+07    1
```

FILE: CASE4.TEM

*****HOLTEC INTERNATIONAL*****

********COMPUTER CODE CROSSTIE********

$Revision: 1.0 $

$Date: 17 Dec 1993 23:30:18 $

$Logfile: C:/RACKHEAT/CONTROL/CROSSTIE.FOV $

THIS PROGRAM WAS VERIFIED BY THE TEST
PERFORMED DURING SALEM 1R11 OUTAGE, OCTOBER 1993

DESCRIPTION OF YOUR JOB
PROGRAM CROSSTIE VERIFICATION CASE 4

```
REACTOR SHUTDOWN DATE:
  10   2  93
OUTAGE UNIT, TIME TO START CROSS-TIE (HR), AND TEMP   LIMIT(F)
  1      490.30      140.30
 CCW FLOW(GPM),SFP FLOW(GPM),CCW TEMP(F),& NET WATER  VOLUME (ft^3)
     3050.00     2040.00        73.00    60000.00
N1,N2,N3,Tao(HR),TaoS(HR)
   0    0    0    240.00      60.00
RP(MW), CF, BP1(MWD/MTU), BP2, BP3, UW(Kg)
3411.0   1.0       .00         .00         .00 461.00
FH BUILDING AMBIENT TEMP(F), RELATIVE HUMIDITY(%)
      75.00         .60
THE ENDING TIME(HR)
     624.00
```

Heat Exchanger Temperature effectiveness p= .3473

	UNIT 1				UNIT 2			
	(POOL)	(HT-TO-HX)	(HT-LOSS)		(POOL)	(HT-TO-HX)	(HT-LOSS)	
TIME	T1	Q1	Qls1	HX1	T2	Q2	Qls2	HX2
(HR)	(F)	(BTU/HR)	(BTU/HR)		(F)	(BTU/HR)	(BTU/HR)	
.00	77.3	.2245E+07	.27E+05	1	78.6	.2945E+07	.37E+05	1
490.00	77.3	.2245E+07	.27E+05	1	78.6	.2945E+07	.37E+05	0
580.58	77.3	.2245E+07	.27E+05	0	140.3	.1716E+07	.13E+07	1

FILE: CASE5.TEM

*****HOLTEC INTERNATIONAL*****

********COMPUTER CODE CROSSTIE********

$Revision: 1.0 $

$Date: 17 Dec 1993 23:30:18 $

$Logfile: C:/RACKHEAT/CONTROL/CROSSTIE.FOV $

THIS PROGRAM WAS VERIFIED BY THE TEST
PERFORMED DURING SALEM 1R11 OUTAGE, OCTOBER 1993

DESCRIPTION OF YOUR JOB
PROGRAM CROSSTIE VERIFICATION CASE 5

```
REACTOR SHUTDOWN DATE:
  10   2  93
OUTAGE UNIT, TIME TO START CROSS-TIE (HR), AND TEMP   LIMIT(F)
  1      448.50      123.50
 CCW FLOW(GPM),SFP FLOW(GPM),CCW TEMP(F),& NET WATER  VOLUME (ft^3)
     2100.00      2460.00       77.50    59000.00
N1,N2,N3,Tao(HR),TaoS(HR)
   61   64   68    240.00      60.00
RP(MW), CF, BP1(MWD/MTU), BP2, BP3, UW(Kg)
3411.0     .9  41300.00  27760.00  15240.00 461.00
FH BUILDING AMBIENT TEMP(F), RELATIVE HUMIDITY(%)
      68.50         .55
THE ENDING TIME(HR)
     520.00
```

Heat Exchanger Temperature effectiveness p= .4824

	UNIT 1				UNIT 2			
	(POOL)	(HT-TO-HX)	(HT-LOSS)		(POOL)	(HT-TO-HX)	(HT-LOSS)	
TIME	T1	Q1	Qls1	HX1	T2	Q2	Qls2	HX2
(HR)	(F)	(BTU/HR)	(BTU/HR)		(F)	(BTU/HR)	(BTU/HR)	
.00	81.8	.2173E+07	.10E+06	1	83.2	.2881E+07	.11E+06	1
240.00	81.8	.2173E+07	.10E+06	1	83.3	.2881E+07	.11E+06	1
240.50	81.9	.2358E+07	.10E+06	1	83.3	.2881E+07	.11E+06	1
317.46	120.4	.2148E+08	.67E+06	1	83.3	.2881E+07	.11E+06	1
317.59	120.4	.2148E+08	.67E+06	1	83.3	.2881E+07	.11E+06	1
317.72	120.4	.2148E+08	.67E+06	1	83.3	.2881E+07	.11E+06	1
448.39	115.5	.1892E+08	.56E+06	1	83.3	.2881E+07	.11E+06	0
502.95	113.8	.1808E+08	.53E+06	0	123.5	.2244E+07	.75E+06	1
504.98	123.7	.1781E+08	.76E+06	1	113.5	.2476E+07	.52E+06	0
519.91	114.4	.1781E+08	.54E+06	0	123.5	.2244E+07	.75E+06	1

FILE: CASE6.TEM

*****HOLTEC INTERNATIONAL*****

********COMPUTER CODE CROSSTIE********

```
$Revision:   1.0  $
$Date:   17 Dec 1993 23:30:18  $
$Logfile:   C:/RACKHEAT/CONTROL/CROSSTIE.FOV  $

  THIS PROGRAM WAS VERIFIED BY THE TEST
  PERFORMED DURING SALEM 1R11 OUTAGE, OCTOBER 1993


 DESCRIPTION OF YOUR JOB
  PROGRAM CROSSTIE VERIFICATION CASE 6


 REACTOR SHUTDOWN DATE:
   10   2  93
 OUTAGE UNIT, TIME TO START CROSS-TIE (HR), AND TEMP   LIMIT(F)
   1      454.50      118.90
  CCW FLOW(GPM),SFP FLOW(GPM),CCW TEMP(F),& NET WATER  VOLUME (ft^3)
      3050.00      2460.00        70.00    59000.00
 N1,N2,N3,Tao(HR),TaoS(HR)
    61   64   68    240.00      60.00
 RP(MW), CF, BP1(MWD/MTU), BP2, BP3, UW(Kg)
 3411.0    .9  41300.00  27760.00  15240.00 461.00
 FH BUILDING AMBIENT TEMP(F), RELATIVE HUMIDITY(%)
       67.50          .55
 THE ENDING TIME(HR)
      600.00

 Heat Exchanger Temperature effectiveness p=  .3773
```

	UNIT 1				UNIT 2			
	(POOL)	(HT-TO-HX)	(HT-LOSS)		(POOL)	(HT-TO-HX)	(HT-LOSS)	
TIME	T1	Q1	Qls1	HX1	T2	Q2	Qls2	HX2
(HR)	(F)	(BTU/HR)	(BTU/HR)		(F)	(BTU/HR)	(BTU/HR)	
.00	73.9	.2225E+07	.50E+05	1	75.2	.2935E+07	.58E+05	1
240.00	73.9	.2225E+07	.50E+05	1	75.2	.2935E+07	.58E+05	1
240.50	73.9	.2410E+07	.50E+05	1	75.2	.2935E+07	.58E+05	1
315.50	108.3	.2177E+08	.43E+06	1	75.2	.2935E+07	.58E+05	1
316.00	108.3	.2176E+08	.43E+06	1	75.2	.2935E+07	.58E+05	1
316.50	108.3	.2175E+08	.43E+06	1	75.2	.2935E+07	.58E+05	1
454.00	103.6	.1903E+08	.36E+06	1	75.2	.2935E+07	.58E+05	0
511.87	102.0	.1814E+08	.33E+06	0	118.9	.2349E+07	.64E+06	1
515.19	118.9	.1777E+08	.64E+06	1	100.5	.2683E+07	.31E+06	0
540.88	101.6	.1772E+08	.32E+06	0	118.9	.2349E+07	.64E+06	1
544.37	118.9	.1735E+08	.64E+06	1	99.8	.2693E+07	.30E+06	0
570.99	100.8	.1732E+08	.31E+06	0	118.9	.2349E+07	.64E+06	1
574.72	118.8	.1694E+08	.64E+06	1	98.9	.2705E+07	.29E+06	0

Salem Generating Station Units 1 and 2

Calculation S-C-SF-MEE-1679, Rev. 0

Salem Generating Station, Units 1 and 2

S-C-SF-MEE-1679, Rev. 0

SFP Cooling System Capability With Core Offload Starting 100-hours After Shutdown

EE No.:	**S-C-SF-MEE-1679**	**Rev. No.:**	0	**Date:**	6/14/02
TITLE:	SFP System Cooling Capability with Core Offload Starting 100-hours After Shutdown				
Periodic Review Required:	**Yes**	**No**	X	**Order No.:**	N/A

TABLE OF CONTENTS

TABLE OF CONTENTS 2
REVISION SUMMARY 2
1.0 PURPOSE 3
2.0 SCOPE 3
3.0 DISCUSSION 3
3.1 Background 4
3.2 Assumptions/Initial Conditions 4
3.3 Basic Parameters 5
3.4 Methodology 5
3.5 Inherent Conservatisms 5
3.6 Evaluation 6
4.0 CONCLUSION/RECOMMENDATION 10
5.0 REFERENCES 11
6.0 EFFECTS ON OTHER TECHNICAL DOCUMENTS 11
7.0 SIGNATURES 12

ATTACHMENT A – Decay Heat Spread Sheets (5 Pages)
ATTACHMENT B – River Water Temperature Analysis (8 Pages)
ATTACHMENT C – Heat Exchanger Data Sheets at Various Temperatures (11 Pages)
ATTACHMENT D – Pool Evaporative Heat Losses (1 Page)
ATTACHMENT E – Reference Documents (4 pages)
ATTACHMENT F – CC Temperature Assumption Validation (6 pages)

REVISION SUMMARY

Revision #	Description
0	Original Issue

1.0 PURPOSE

This document evaluates SFP Cooling Capabilities with 100-hours of in-vessel decay, rather than the 168-hour delay currently required by technical specifications. As such, this evaluation is intended to provide a technical basis for a Licensing Change Request (S02-03) to the USNRC to revise the technical specifications of both Salem Unit 1 and Salem Unit 2. This evaluation, along with the LCR, covers the time period up through 2010.

2.0 SCOPE

This evaluation applies to both Salem Unit 1 and Salem Unit 2, and covers the period from October 15th through May 15th, annually. During the remainder of the year (May 16th through October 14th), the current 168-hour technical specification requirement will remain intact. This evaluation deals only with decay heat resulting from the radioactive decay of fuel rods loaded into the Spent Fuel Pools. It does not address radiological dose issues associated with fuel transfer to the SFP. Radiological dose issues are handled separately.

3.0 DISCUSSION

The Salem UFSAR, Section 9.1.3.1 makes the following statements:

"The Spent Fuel Pool Cooling System maintains pool temperature at or below 149°F, provided both SFP heat exchangers are available. If only one heat exchanger is available, pool temperature is limited to 180°F."

Later, in Section 9.1.3.2, the UFSAR makes additional clarifying statements:

"In 1998, additional spent fuel pool heat removal analyses were performed. The analyses addressed potential full-core off-loads during upcoming refueling outages as well as end of plant life. These analyses concluded one pump and one heat exchanger can maintain pool temperature below 149°F under all combinations of decay time and CCW temperature except minimum decay times and very high cooling water temperatures. Under these later conditions, in vessel decay-time would be extended or parallel heat exchanger operation would be used to maintain pool temperature below 140°F. [1]"

In view of the above statements, the questions to be resolved in this evaluation are:

1. With in-vessel delay time reduced from 168-hours to 100-hours, during the period from October 15th to May 15th (when CCW temperatures are relatively low), can the SFP cooling system maintain pool temperatures at or below 149°F with both heat exchangers available and below 180°F with one heat exchanger available? If so, is there a time limit on this activity based upon background heatwithin the Spent Fuel Pool?
2. If pool temperature is predicted to rise above 149°F, can temperatures of both pools be maintained below 149°F by employing parallel heat exchanger operations? If so, with what frequency are the heat exchangers shifted between pools to maintain 149°F?

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[1] UFSAR Section 9.1.3.2 states parallel heat exchanger operation would be used in high heat, high CCW temperature conditions to maintain pool temperatures below 140°F. This is a discrepancy since both of the previous statements, and the Salem design calculations are based upon maintaining pool temperatures below 149°F when two heat exchangers are available. Notification 20100275 has been written to address this discrepancy

3.1 Background

There are two reasons why in-vessel decay is required before moving a fresh, hot core into the SFP, the potential for radiation doses and pool cooling requirements. With regard to pool cooling, decay heat rates from previously irradiated fuel elements constantly decrease as the fission products and heavy elements decay. Therefore, the longer the elements are allowed to decay within the reactor vessel, the less heat duty is transferred to the SFP.

The 168-hour limit is based upon the capability of the SFP cooling system when River temperatures, and the consequent CCW temperatures, are at their highest. These analyses considered the River temperature to be at 90°F, with CCW at 99°F. This condition has never occurred at Salem, but if it did, it would occur in late July or early August, when River temperatures typically peak. While the 168-hour delay conservatively covers the entire year, it imposes an unnecessary penalty on plant operators in the cooler months, when refuelings are typically scheduled.

In view of the above, this evaluation considers SFP cooling capabilities if a 100-hour delay is imposed prior to defueling, and is restricted to defuelings that occur between October 15th and May 15th.

3.2 Assumptions/Initial Conditions

1. Both SFPC heat exchangers will be assumed to have 6% of the tubes plugged. This is a conservative assumption because the highest tube current tube plugging is 4% (Assumption 5.0.c of Reference 5.1), and there are no reasons to expect additional plugging in these pure water to treated water exchangers.
2. SFPC (one pump) flow to the heat exchanger is 2500 gpm (Reference 5.1, paragraph 6.2). When two heat exchangers are aligned to a single pool, 2 pumps will be assumed running with an average flow rate of approximately 1500 gpm per heat exchanger (Reference 5.1, paragraph 4.0.e).
3. CCW flow to the SFP heat exchanger is 3000 gpm (Assumption 5.0.a of Reference 5.1).
4. SFP heat exchanger fouling factor will be conservatively held equal to or greater than its design basis value (0.001075). The heat exchanger data sheet is shown in Reference 5.7.
5. Reactor power is conservatively considered to be 3479 MWt (1.02 x 3411 MWt). This envelopes the current 3459MWt based upon the 1.4% power uprate (Reference 5.3, Input 3.19).
6. Based on current refueling programs, fuel assemblies while in the reactor vessel will be assumed to be expended in accordance with the following (Reference 5.2):
   - 76 assemblies with 17 months of effective full power operation
   - 76 assemblies with 34 months of effective full power operation
   - 41 assemblies with 51 months of effective full power operation.
7. Defueling of 193 assemblies will be assumed to require 46 hours as per current scheduling (Reference 5.3, Input 3.9). Therefore defueling is complete 146 hours (6.08 days) after shutdown (100 hours + 46 hours). Actual defueling times for the past 4 Salem outages are listed below (Reference 5.4):
   a. 1R13 60 hours
   b. 1R14 53 hours
   c. 2R10 58 hours
   d. 2R11 53 hours
8. There are currently 920 fuel assemblies in the Unit 1 SFP (as of 1R14 in April 2001) and 812 elements in the Unit 2 pool (as of 2R12 in April 2002). (Reference 5.4).

9. Background heat in the Unit 1 SFP was 2.31 x 10^6 Btu/hour prior to outage 1R13 in 1999 (Reference 5.1).
10. Background heat in the Unit 1 SFP at end of life (i.e. with a full pool) is 8.46 x 10^6 Btu/hr (Reference 5.5).
11. The maximum number of fuel elements that can be loaded into a Salem SFP is 1632 (Reference 5.11).
12. Background heat in the pool at any given refueling between the present and end of life (or full pool) is assumed to be a straight line between 2.31 x 10^6 Btu/hour (Input #9) and 8.46 x 10^6 Btu/hour (Input #10).
13. Net thermal capacity of SFP water at the end of life with all fuel racks filled (thereby minimizing available water volume) is 1.96 x 10^6 Btu/°F, as shown on page 22 of Reference 5.5.

3.3 Basic Parameters

The basic parameters that are used throughout the remainder of this evaluation are reiterated below:

1. Refueling operations are conducted during the period from October 15 to May 15.
2. All 193 fuel assemblies are off-loaded to the Spent Fuel Pool (full core offload).
3. In addition to the fresh 193 assemblies, the background heat (old assemblies) in the pool represents the background heat that will exist in the year 2010.
4. River temperatures are determined from 30 years of historical data.
5. Defueling begins 100 hours after reactor shutdown.
6. All SFP heat removal is via the Spent Fuel Pool Cooling System. No credit is taken for heat transfer via evaporative cooling or to the SFP (concrete) structure.

3.4 Methodology

1. Determine the decay heat rate from the off-loaded core using USNRC Branch Technical Position ASB 9-2 (Reference 5.6).
2. Determine background heat that will exist in the SFP in the year 2010.
3. Evaluate Delaware River temperatures during the period from October through May.
4. Benchmark the SFP heat exchanger design basis parameters against the Joseph Oats (Manufacturer's) data sheet, using the HTC-STX heat exchanger design computer program.
5. Using the benchmarked heat exchanger model in the HTC-STX heat exchanger computer program, determine heat duties with various SFP temperatures and CCW temperature appropriate for the time period.
6. Evaluate the ability of the SFP Cooling System to maintain pool temperature limits.

3.5 Inherent Conservatisms

This analysis considers heat removal from the Salem Spent Fuel Pools using only forced cooling provided by the SFPC heat exchangers. By relying exclusively on the SFPC heat exchangers, the analysis contains several substantial conservatisms as described below. These conservatisms could be quantified and credited in this calculation. However, at this time they will be left as providing additional temperature margins.

1 No credit is taken for evaporative cooling, i.e. pool bulk temperature cooling resulting from evaporation at the surface of the SFP. Reference 5.5 indicates that evaporative cooling contributes 0.86 x

10^6 Btu/hour at 150°F and 3.87 x 10^6 Btu/hour at 180°F. Consequently, if the pool reaches 180°F, evaporative cooling amounts to about 10% of the peak heat load in the SFP.

2 No credit is taken for cooling through the concrete structure of the pool. Heat is conducted through the pool steel liner, concrete structure, and ultimately to the cooler environment beyond the structure. The higher the pool water temperature, the more heat transmitted through the structure.

3 RHR cooling continues to provide forced cooling to the SFP with all fuel elements removed to the SFP as long as the refueling canal remains flooded and the transfer gate is open. The cooler water in the reactor vessel and refueling canal will transfer to the SFP via natural circulation through the transfer gate. This potential cooling source is never credited in any analysis or procedure.

3.6 Evaluation

__Core Decay Heat__

Decay heat from the newly discharged core is determined using the USNRC Branch Technical Position ASB 9-2, Residual Decay Heat for Light-Water Reactors for Long-Term Cooling (Reference 5.6). This is the most conservative of the various computer codes accepted by the USNRC for calculating fuel element decay heat, and is conservatively used here without scaling factors or other adjustments.

As shown in Attachment A, pages A1 through A4, the residual heat from the 193 assembly offload to the SFP is shown to be 3.72 x 10^7 Btu/hr as summarized in the following table. The 146 hours after shutdown includes the 100-hour delay plus an additional 46 hours to offload the 193 assemblies. A 10% uncertainty factor is included per the BTP.

This is the highest heat load in the pool from the newly discharged core, and it exists only at the moment that the final assembly is moved into the pool. After that time, the heat load continuously decays to lower values. Nonetheless, this value is used throughout this evaluation as the heat in the SFP.

Number of Assemblies	Reactor Power	Time to Off-Load After Shutdown	Effective Full Power Hours of Burnup	Calculated Decay Heat
76	3479 MWt	6.08 days (146 hrs)	12,410 (17 mos.)	1.31 x 10^7 Btu/hr
76	3479 MWt	6.08 days (146 hrs.	24,820 (34 mos.)	1.36 x 10^7 Btu/hr
41	3479 MWt	6.08 days (146 hrs)	37,230 (51 mos.)	7.43 x 10^6 Btu/hr
Heavy Elements (all assemblies)	3479 MWt	6.08 days (146 hrs)	Same as above	3.03 x 10^6 Btu/hr
Core Total				**3.72 x 10^7 Btu/hr**
Background Heat[2]				6.8 x 10^6 Btu/hr
Peak Pool Heat Load in 2010				**4.4 x 10^7 Btu/hr**

[2] Derivation of background heat is discussed in the next paragraph.

Background Heat

Background heat in the SFP is based on Unit 1, since the Unit 1 SFP contains more spent fuel rods than does the Unit 2 pool (based on approximately 3 more refueling outages by Unit 1). With 965 elements in the pool as of October 2002 (1R15) and at the current rate of 76 elements being permanently discharged per refueling cycle, the Unit 1 pool will be full in approximately 8 more refueling cycles (e.g. by the year 2014). Page A5 of Attachment A shows a straight-line graph of decay heat from 2002 to 2014, based upon Input/Assumptions Nos. 8 through 12.

As seen on page A5 of Attachment A, the background decay heat in the Unit 1 SFP in year 2010 is 6.8×10^6 Btu/hour. When added to the freshly offloaded core, the peak total pool heat in the year 2010 is 4.4×10^7 Btu/hr.

Delaware River/CCW Temperature

As shown in Attachment B, pages B1 through B8, the average monthly temperature in the Delaware River (measured at Reedy Island) between the months of October and May are 63°F and below. These temperatures are based upon 30 years of weekly data recorded at Reedy Island, a location just upstream of Salem and Hope Creek. These pages also show that on average, inlet temperatures at the plant run 3°F higher than Reedy Island. Even though there have been measurements of plant temperatures as much as 5°F higher (and as low as 1°F) than Reedy Island, the 3°F average is considered conservative in a condition where one of the two Salem Units is shutdown. The Salem Units account for nearly all of the output heat in the River. Hope Creek has a cooling tower, through which most waste heat is released to the environment. Therefore, with one of the two Salem Units shutdown (and only discharging waste reactor heat), historical average differentials between the plant and Reedy Island are conservative.

The CC supply temperature is determined in Attachment F, based on a Service Water inlet temperature of 66°F, with both one and two CCW heat exchangers aligned. Using both CCW heat exchangers during the few days that SFP heat loads are at their peak would have beneficial effects with regards to minimizing the CC supply temperature. However, since both CCW heat exchangers may not be available when fuel is moved, this analysis is being performed assuming only one CCHX is available. From Attachment F, the CCW supply temperature is 71°F with one CCHX and a Service Water inlet temperature of 66°F (with two SFHXs).

Temperature	Description
63°F	Delaware River historical data
3°F	Reedy Island to plant intake
66°F	Service Water Inlet Temperature
71°F	CCW Temperature Based on 66°F SW Inlet, as shown in Attachment F

Use of 71°F for this analysis is considered appropriate for two reasons:

1 This evaluation provides a technical basis for reducing the in-vessel decay time for defueling from 168-hours to 100-hours during the months from mid-October to mid-May. Before fuel is actually transferred, the Salem Decay Heat Management Program is implemented in accordance with Outage Risk Management procedures (Reference 5.10) for the actual conditions in existence at outage time. In the case of a particularly mild winter or particularly hot summer where River temperatures might be well

above predicted temperatures, fuel would not be transferred until the Decay Heat Management Program indicated pool temperature limits would be achieved.[3]

2 The inherent conservatisms in this analysis (i.e. evaporative cooling, structure cooling, RHR cooling) are of sufficient magnitude to account for any foreseeable changes in river temperatures or other potentially non-conservative assumptions. Hence, this calculation is considered to be sufficiently conservative.

Both SFPC Heat Exchangers

As shown in Attachment C, pages C1 through C3, the HTC-STX heat exchanger computer code, Version 3.6, is benchmarked against the original Joseph Oats data sheet from Reference 5.7. It should be noted that the HTC-STX data sheet says that SFPC surface area is over-designed by 7.55%. This is consistent with HOLTEC International's analysis of this same heat exchanger (Reference 5.5). In Reference 5.5, HOLTEC concluded that the SFPC heat exchanger was over-designed by 7.04%. Based on their analysis, HOLTEC concluded that the design basis heat duty should have been 12.78×10^6 Btu/hour rather than the 11.94×10^6 Btu/hour of the Joseph Oats data sheet.

The same heat exchanger model that produced the benchmarked data sheet was then changed to incorporate 6% tube plugging and to revise shell-side (CCW) inlet temperature to 71°F. Using this model, heat duties were calculated for various spent fuel pool temperatures. As shown on Attachment C, page C4, the peak spent fuel pool heat rate of 4.4×10^7 Btu/hour is removed at a pool temperature of 161°F and a fouling factor of 0.00105. This says that if only one SFP heat exchanger and one SFP pump are used on the hot pool, pool temperature will eventually rise to 161°F.

Technically, 161°F is not a limitation on the spent fuel pool as it is qualified to at least 180°F. A 161°F temperature in the pool can cause moisture and humidity on the refueling floor due to evaporative losses from the pool, but does not violate the design basis. Placing the heat exchanger from the non-refueling unit in parallel with the hot pool unit (crosstie mode), temperature in the hot pool can be reduced to 128.5°F, since that is the temperature that results from a heat duty of 2.2×10^7 Btu/hr per heat exchanger (see page C5)[4]. Since the non-refueling pool will contain only background heat, it will begin to heat up at 3.5°F per hour (6.8×10^6Btu/hr/1.96 Btu/°F). At this rate, it would take 14 hours to heat from 100°F to 149°F[5]. In the meantime, during that same 14 hours, the hot core will have decayed by 1×10^6 Btu/hr, or approximately 2% of its peak value.

At the end of 14 hours, the non refueling pool will have to be cooled by realigning it back to it's unit's heat exchanger. At this time, the hot pool is at 128.5°F and with one heat exchanger still assigned to that pool, the heat up rate is 6.6°F per hour between 128.5°F and 149°F. This allows 3.7 hours to cool down the non-refueling pool before both heat exchangers need to be shifted back to the hot pool. In 3.7 hours, the non-

[3] In October, river temperatures are highest on the day the fuel is offloaded and river temperatures slowly decrease thereafter. With residual heat from the fuel also decaying, SFP cooling capabilities become more conservative with each passing day. In May, however, river temperatures can be expected to slowly increase (typically 2.2°F to 2.3°F per week) after the fuel has been offloaded. This is not conservative, although the decaying residual heat would offset the temperature increases. Nonetheless, to assure that temperature increases after fuel offload do not adversely impact the results of the pre-outage analyses, refueling in May (with 100-hour in-vessel delay) has been limited to May 15th. This assures that the fuel in the pool will be well decayed as River temperatures rise into the month of June.

[4] This analysis assumes that pre-outage assessments of SFPC capabilities will result in operators placing the 2nd heat exchanger in parallel with the hot pool at some time either before or shortly after the pool heats above 128.5°F.

[5] During the period when the non-refueling pool is not being cooled because its heat exchanger is being used on the hot-pool, the temperature in the non-refueling pool could be taken above 149°F. However, this evaluation is based upon activities necessary to maintain both Salem SFPs at temperatures of 149°F or below.

refueling pool can be cooled to 111°F. In the final analysis, both pools will be maintained at 149°F or below as summarized below:

Pool	No. HXs	Average Heat Removal (Btu/hr)	Heat Added (Btu/hr)	Differential (Btu/hr	Heat up or Cool down Rate	Initial Temp.	Final Temp.	Time to Switch HX
Refueling	2	4.4×10^7	4.4×10^7	0	0	128.5°F	128.5°F	14 hrs.
Non-Refuel	0	0	6.8×10^6	$+6.8 \times 10^6$	+3.5°F/hr	100°F	149° F	14 hrs.
Refueling	1	3.2×10^7	4.3×10^7	$+1.3 \times 10^7$	+5.6°F/hr	128.5°F	149°F	3.7 hrs.
Non-Refuel	1	2.7×10^7	6.8×10^6	-2.3×10^7	-10.3°F/hr	149°F	111°F	3.7 hrs.
Refueling	2	5.2×10^7	4.3×10^7	-9×10^6	-4.6°F/hr	149°F	128.5°F	10.8 hrs.
Non-Refuel	0	0	6.8×10^6	$+6.8 \times 10^6$	+3.5°F	111°F	149°F	10.8 hrs.

As can be seen above, the non refueling pool heat exchanger can be shifted between its own pool and the hot pool on a 3.7 hours on, 10.8 hours off basis[6] as long as necessary to maintain both SFPs below 149°F.

In actual practice, it may be desirable to hold both SFPs below some lower temperature (i.e. less than 149°F) in order to minimize the humidity and moisture in the Fuel Handling Building, both from the standpoint of conducting refueling operations and to minimize affects on the FHB ventilation system. The frequency of shifting heat exchangers to maintain some lower pool temperature (135°F for example), will be determined on an outage-by-outage basis via the Decay Heat Management Program pre-outage assessment of SFP heat loads. Judgments can made at just prior to the outage as to what temperatures to control (149°F or lower) and how often, under the specific circumstances of the outage, to swap heat exchangers.

One SFPC Heat Exchanger

Attachment C gives the heat duties through one SFPC heat exchanger with SFP temperatures of 160°F, 161°F, 170°F, and 180°F, as summarized in the following table.

Pool Temperature	CCW Temperature	Heat Capacity	Page No.
161°F	71°F	4.40×10^7 Btu/hour	C4
170°F	71°F	4.80×10^7 Btu/hour	C7
180°F	71°F	5.31×10^7 Btu/hour	C8
Average		4.84×10^7 Btu/hour	

The above table indicates that the average heat removal rate between a pool temperature of 180°F and 161°F is 4.84×10^7 Btu/hour. With a heat input rate of 4.4×10^7 Btu/hour, this leaves an average of 4.4×10^6 Btu/hour available for water temperature cool-down. With the thermal capacity of the water being 1.96×10^6 Btu/°F (see Assumption/Initial Conditions #13), this indicates that a single SFP heat exchanger with a single pump can cool the pool water from 180°F to 161°F in approximately 8.5 hours as shown below.

[6] Cycles times will increase as the SFP heat rate continues to decay. These values are the bounding values

1.96×10^6 Btu/°F/4.4 x 10^6 Btu/hour = 0.445 hours/°F x 19°F = 8.5 hours

If only one SFPC heat exchanger was available to cool both pools, then the pool with only background heat would slowly heat up while the hot pool is being cooled. With a potential background heat of 6.8×10^6 Btu/hour in the year 2010, this pool will heat up at a rate of approximately 3.5°F/hour (6.8×10^6 Btu/hour/1.96×10^6 Btu/°F). The available heat exchanger would be shifted to the background pool when it heats to 180°F. In this case, the hot pool will heat from 161°F to 180°F in approximately 51 minutes (1.96×10^6 Btu/°F/44.0×10^6 Btu/hour = .0445 hours/°F x 19°F = 0.85 hours = 51 minutes), at which time the heat exchanger would be returned to the hot pool. During the hot-pool heat up, the background pool would cool from 180°F to approximately 159°F. The cycle would continue, as shown in the following table, until either the 2nd heat exchanger is returned to service or the core is reloaded into the refueling Unit.

Refueling (Hot) Pool	Time Duration Prior to HX Transfer	Heat up/ Cooldown Rate	Initial Temp	Final Temp	Background Pool	Heat up/ Cooldown Rate	Initial Temp	Final Temp
HX Aligned	17.1 hours	Holding	161°F	161°F	No HX	+3.5°F/hr	120°F	180°F
No HX	0.85 hours	+21.4°F/hr	161°F	180°F	HX Aligned	-24.7°F/hr	180°F	159°F
HX Aligned	6 0 hours	-3.26°F/hr	180°F	161°F	No HX	+3.5°F/hr	159°F	180°F
No HX	0.85 hours	+21.4°F/hr	161°F	180°F	HX Aligned	-24.7°F/hr	180°F	159°F

As shown in the above table, the 6.0-hour (hot pool)/0.85 hour (background pool) cycle can be continued as long as would be necessary to either restore the unavailable heat exchanger or begin transferring hot fuel back into the vessel of the refueling unit. In reality, a 51 minute duration between heat-exchanger shifting may be impractical due to the time it takes to manually swap the exchangers. However, it should be noted that the time durations would increase every time a new cycle begins because the hot fuel in the refueling pool would be rapidly decaying and reducing the amount of heat being transferred to its pool. In addition, the cooling times available prior to each heat exchanger shift are considered to be very conservative and in reality, are expected to be longer. This is the case because (1) the BTP heat loads are very conservative and the heat from the hot pool is expected to be 5% to 10% lower (2) there would be considerable evaporative cooling from the pools at these elevated temperatures (as much as 4×10^6 Btu/hr at 180°F) and (3) the concrete structure would also act to buffer the temperature changes. Furthermore, a more accurate assessment of the pool heat up times will be done prior to a refueling outage, as part of the Decay Heat Management Program, so proper planning on when and if to remove a SFHX from service can be performed.

4.0 CONCLUSION/RECOMMENDATION

During the period from October 15th through May 15th up to and including the year 2010, a fully radiated 193 element core can be off-loaded to a Spent Fuel Pool with a 100-hour in-vessel decay, rather than a 168 hour decay, because the SFPC system is capable of (1) maintaining both Salem pools below 149°F with two SFPC heat exchangers available and (2) maintaining both pools below 180°F with only one heat exchanger available. While this capability meets the requirements of UFSAR Chapter 9.1.3.1,a Technical Specification change will be required because a 168-hour delay is currently required regardless of the time of year or cooling water temperatures.

This conclusion is justified because (1) the Salem Outage Risk Management Program, which includes a pre-outage assessment of the SFP heat loads and heat up rates will assure available SFPC capability prior actually offloading fuel and (2) the inherent conservatisms in this calculation provide for additional cooling sources that are not credited herein. In order to maintain both pools below the required temperature limits, the SFPC heat exchangers may be required to operate in the crosstie mode (i.e. in parallel) for a period of time. as determined by the pre-outage assessment.

The evaluation does not address various practical considerations associated with pool temperatures above 140°F, namely that it is expected that humidity and moisture on the refueling floor will be high and may require special precautions for operations, refueling, or maintenance personnel. Long-term impact on the FHB ventilation system may also become a consideration.

5.0 REFERENCES

5.1 S-C-SF-MDC-1780, Revision 0, Capability of Salem Spent Fuel Pool Heat Exchangers to Maintain 149°F Pool Temperature

5.2 Phone Call with Glenn Schwartz, Salem Fuels of 5/2/02 (see Attachment E)

5.3 S-C-SF-MDC-1800, Revision 2, Decay Heat-up Rates and Curves

5.4 Phone call with Glenn Schwartz, Salem Fuels Department, on 5-3-02 (see Attachment E)

5.5 S-C-SF-MDC-1240, Revision 0, SFP Thermal-Hydraulic Calculation (HOLTEC International)

5.6 BTP ASB 9-2 Revision 2 of July 1981, USNRC Standard Review Plan 9.2.5, Ultimate Heat Sink, NUREG 0800

5.7 PSBP 301110, Revision 10, Westinghouse Instruction Manual, Auxiliary Heat Exchangers

5 8 Phone call with Kevin King, PSE&G Engineering, on 5/6/02 (see Attachment E)

5.9 LCR S02-03

5.10 NC.OM-AP.ZZ-0001, Revision 3, Outage Risk Assessment

5.11 T/S 5.6.3, Fuel Storage Capacity

6.0 EFFECTS ON OTHER TECHNICAL DOCUMENTS

The following procedure changes are required upon NRC approval of the LCR:

1. The appropriate operating procedures (S1(2).OP-SO.SF-0009 &/or 0002 &/or S1(2).OP-IO.ZZ-0001) will need to be revised to ensure the maximum Service Water flow is established through the CCHXs during refueling outages when the core is offloaded into the Spent Fuel Pool, in order to minimize CC temperature and maximize SFHX heat load. This would also be applicable to the non-outage unit if the SF cross-tie were utilized. This can be accomplished by any of the following means, depending on the conditions existing at the time:

   A. Set the CC temperature for the available CCHXs in accordance with S1(2).OP-SO.CC-0002 to the minimum allowable for the applicable mode. This will result in the SW flow going to the flow control setpoint of 10,000 gpm. OR

   B. Place the CCHX in the flow control mode. Flow will be maintained at the flow control setpoint of 10,000 gpm. OR

   C. If a SW header on the outage unit is removed from service rendering its CCHX unavailable, and the available CCHX control valves are gagged in position, the position should be set to ensure at least 10,000 gpm SW flow, but less than the maximum limit of 12,500 gpm.

EE No.:	S-C-SF-MEE-1679	Rev. No.:	0	Date:	6/14/02

7.0 SIGNATURES

Preparer:	T. J. DelGaizo, Main Line Engineering	Date:	6/12/02
Peer Reviewer:	NA	Date:	NA
Verifier:	J. Wiedemann, Main Line Engineering	Date:	6/13/02
KEK Functional Supervisor:	G. Morrison, PSEG Nuclear	Date:	6/14/02

SFP Decay Heat

76 Assemblies with 24820 EFPH (34 months)

Days after Reactor Shutdown when Refueling Begins: 4.1667

Infinite Core	n	An Fit Coeff.	an Fit Coeff.	S.D. (days)	ts (seconds)	P/Po Power Fr.	Po Full Power	P (Btu/hr)	No Elem.	Bt/hr
	1	0.5980	1.772E+00	6.08	5.26E+05	0 00E+00	6.15E+07	0.00E+00		
	2	1.6500	5.774E-01	6.08	5.26E+05	0.00E+00	6.15E+07	0.00E+00		
	3	3.1000	6.743E-02	6.08	5.26E+05	0.00E+00	6.15E+07	0.00E+00		
	4	3.8700	6.214E-03	6.08	5.26E+05	0.00E+00	6.15E+07	0.00E+00		
	5	2.3300	4.739E-04	6.08	5.26E+05	7.77E-111	6.15E+07	4.78E-103		
	6	1.2900	4.810E-05	6.08	5.26E+05	6.76E-14	6.15E+07	4.16E-06		
	7	0.4620	5.344E-06	6.08	5.26E+05	1.39E-04	6.15E+07	8.57E+03		
	8	0 3280	5.716E-07	6.08	5.26E+05	1.21E-03	6.15E+07	7.47E+04		
	9	0.1700	1.036E-07	6.08	5.26E+05	8.05E-04	6.15E+07	4.95E+04		
	10	0.0865	2.959E-08	6.08	5.26E+05	4.26E-04	6.15E+07	2.62E+04		
	11	0.1140	7.585E-10	6.08	5.26E+05	5.70E-04	6.15E+07	3.51E+04		
						3.15E-03	6.15E+07	1.94E+05	76	1.47E+07

1/3Core-2Cycles	n	An Fit Coeff.	an Fit Coeff.	Op.Time (days)	to + ts (seconds	P/Po Power Fr.	Po Full Power	P (Btu/hr)		
	1	0.5980	1.772E+00	1040	8.99E+07	0.00E+00	6.15E+07	0.00E+00		
	2	1.6500	5.774E-01	1040	8.99E+07	0.00E+00	6.15E+07	0.00E+00		
	3	3.1000	6.743E-02	1040	8.99E+07	0.00E+00	6.15E+07	0.00E+00		
	4	3.8700	6.214E-03	1040	8.99E+07	0.00E+00	6.15E+07	0.00E+00		
	5	2.3300	4.739E-04	1040	8.99E+07	0.00E+00	6.15E+07	0.00E+00		
	6	1.2900	4.810E-05	1040	8.99E+07	0.00E+00	6.15E+07	0.00E+00		
	7	0.4620	5.344E-06	1040	8.99E+07	5.88E-212	6.15E+07	3.62E-204		
	8	0.3280	5.716E-07	1040	8.99E+07	8.01E-26	6.15E+07	4.93E-18		
	9	0.1700	1.036E-07	1040	8.99E+07	7.68E-08	6.15E+07	4.73E+00		
	10	0.0865	2.959E-08	1040	8.99E+07	3.03E-05	6.15E+07	1.86E+03		
	11	0.1140	7.585E-10	1040	8.99E+07	5.32E-04	6.15E+07	3.28E+04		
						5.63E-04	6.15E+07	3.46E+04	76	2.63E+06
D.H. Rate						2.91E-03	6.15E+07	1.79E+05	76	1.36E+07

	Elements In Pool	2010 total in Pool	P (Btu/hr)
1/3 for 2 cycles (76 assemblies)			1.36E+07
1/3 for 3 cycles (41 assemblies)			7.43E+06
1/3 for 1 cycle (76 assemblies)			1.31E+07
Background	956	1412	6 80E+06
Heavy Elements			3.03E+06
TOTAL			4.39E+07

SFP Decay Heat

76 Assemblies with 12410 EFPH (17 months)

Days after Reactor Shutdown when Refueling Begins: 4.1667

Infinite Core	n	An Fit Coeff.	an Fit Coeff.	S.D. (days)	ts (seconds)	P/Po Power Fr.	Po Full Power	P (Btu/hr)	No. Elem	Bt/hr
	1	0.5980	1.772E+00	6.08	5.26E+05	0.00E+00	6.15E+07	0.00E+00		
	2	1.6500	5.774E-01	6.08	5.26E+05	0.00E+00	6.15E+07	0.00E+00		
	3	3.1000	6.743E-02	6.08	5.26E+05	0.00E+00	6.15E+07	0.00E+00		
	4	3.8700	6.214E-03	6.08	5.26E+05	0.00E+00	6.15E+07	0.00E+00		
	5	2.3300	4.739E-04	6.08	5.26E+05	7.77E-111	6.15E+07	4.78E-103		
	6	1.2900	4.810E-05	6.08	5.26E+05	6.76E-14	6.15E+07	4.16E-06		
	7	0.4620	5.344E-06	6 08	5.26E+05	1.39E-04	6.15E+07	8.57E+03		
	8	0.3280	5.716E-07	6.08	5.26E+05	1.21E-03	6.15E+07	7.47E+04		
	9	0.1700	1.036E-07	6.08	5.26E+05	8.05E-04	6.15E+07	4.95E+04		
	10	0 0865	2.959E-08	6 08	5.26E+05	4.26E-04	6.15E+07	2.62E+04		
	11	0.1140	7.585E-10	6.08	5.26E+05	5.70E-04	6.15E+07	3.51E+04		
						3.15E-03	6.15E+07	1.94E+05	76	1.47E+07

1/3Core-1Cycle	n	An Fit Coeff.	an Fit Coeff.	Op.Time (days)	to + ts (seconds	P/Po Power Fr.	Po Full Power	P (Btu/hr)	No. Elem	Bt/hr
	1	0.5980	1.772E+00	523	4.52E+07	0 00E+00	6.15E+07	0.00E+00		
	2	1.6500	5.774E-01	523	4.52E+07	0.00E+00	6.15E+07	0.00E+00		
	3	3.1000	6.743E-02	523	4.52E+07	0 00E+00	6.15E+07	0.00E+00		
	4	3.8700	6.214E-03	523	4.52E+07	0.00E+00	6.15E+07	0.00E+00		
	5	2.3300	4.739E-04	523	4.52E+07	0 00E+00	6.15E+07	0.00E+00		
	6	1.2900	4.810E-05	523	4.52E+07	0.00E+00	6.15E+07	0.00E+00		
	7	0.4620	5.344E-06	523	4.52E+07	2.86E-108	6.15E+07	1.76E-100		
	8	0.3280	5.716E-07	523	4.52E+07	9.86E-15	6.15E+07	6.07E-07		
	9	0.1700	1.036E-07	523	4.52E+07	7.86E-06	6.15E+07	4 84E+02		
	10	0.0865	2.959E-08	523	4.52E+07	1.14E-04	6.15E+07	6.99E+03		
	11	0.1140	7.585E-10	523	4 52E+07	5.51E-04	6.15E+07	3.39E+04		
						6.72E-04	6.15E+07	4.14E+04	76	3.14E+06
D.H. Rate						2.80E-03	6.15E+07	1.72E+05	76	1.31E+07

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SFP Decay Heat

41 Assemblies with 37,230 EFPH (51 months)

Days after Reactor Shutdown when Refueling Begins 4.1667

Infinite Core	n	An Fit Coeff.	an Fit Coeff	S.D. (days)	ts (seconds)	P/Po Power Fr.	Po Full Power	P (Btu/hr)	No. Elem.	Bt/hr
	1	0.5980	1.772E+00	6.08	5.26E+05	0 00E+00	6.15E+07	0 00E+00		
	2	1.6500	5.774E-01	6.08	5.26E+05	0 00E+00	6.15E+07	0 00E+00		
	3	3.1000	6.743E-02	6.08	5.26E+05	0 00E+00	6.15E+07	0.00E+00		
	4	3 8700	6.214E-03	6 08	5.26E+05	0.00E+00	6.15E+07	0.00E+00		
	5	2.3300	4.739E-04	6 08	5.26E+05	7.77E-111	6.15E+07	4.78E-103		
	6	1.2900	4.810E-05	6 08	5.26E+05	6.76E-14	6 15E+07	4.16E-06		
	7	0 4620	5 344E-06	6 08	5 26E+05	1.39E-04	6 15E+07	8.57E+03		
	8	0.3280	5 716E-07	6.08	5 26E+05	1.21E-03	6.15E+07	7.47E+04		
	9	0.1700	1.036E-07	6 08	5.26E+05	8.05E-04	6.15E+07	4.95E+04		
	10	0 0865	2.959E-08	6.08	5.26E+05	4 26E-04	6.15E+07	2.62E+04		
	11	0.1140	7.585E-10	6.08	5.26E+05	5.70E-04	6 15E+07	3.51E+04		
						3.15E-03	6.15E+07	1.94E+05	41	7.96E+06

1/3Core-3 Cycles	n	An Fit Coeff	an Fit Coeff.	Op.Time (days)	to + ts (seconds	P/Po Power Fr.	Po Full Power	P (Btu/hr)		
	1	0 5980	1.772E+00	1557	1.35E+08	0.00E+00	6.15E+07	0.00E+00		
	2	1.6500	5.774E-01	1557	1.35E+08	0 00E+00	6.15E+07	0.00E+00		
	3	3.1000	6 743E-02	1557	1.35E+08	0.00E+00	6.15E+07	0.00E+00		
	4	3.8700	6.214E-03	1557	1.35E+08	0.00E+00	6.15E+07	0 00E+00		
	5	2.3300	4 739E-04	1557	1.35E+08	0 00E+00	6.15E+07	0.00E+00		
	6	1.2900	4 810E-05	1557	1.35E+08	0.00E+00	6.15E+07	0 00E+00		
	7	0.4620	5.344E-06	1557	1.35E+08	0.00E+00	6 15E+07	0 00E+00		
	8	0.3280	5.716E-07	1557	1.35E+08	6.50E-37	6.15E+07	4.00E-29		
	9	0 1700	1.036E-07	1557	1.35E+08	7.51E-10	6.15E+07	4.62E-02		
	10	0 0865	2.959E-08	1557	1.35E+08	8 07E-06	6 15E+07	4.97E+02		
	11	0.1140	7.585E-10	1557	1.35E+08	5.15E-04	6 15E+07	3 17E+04		
						5 23E-04	6.15E+07	3.22E+04	41	1.32E+06
D.H. Rate						2.95E-03	6.15E+07	1.81E+05	41	7.43E+06

SFP Decay Heat

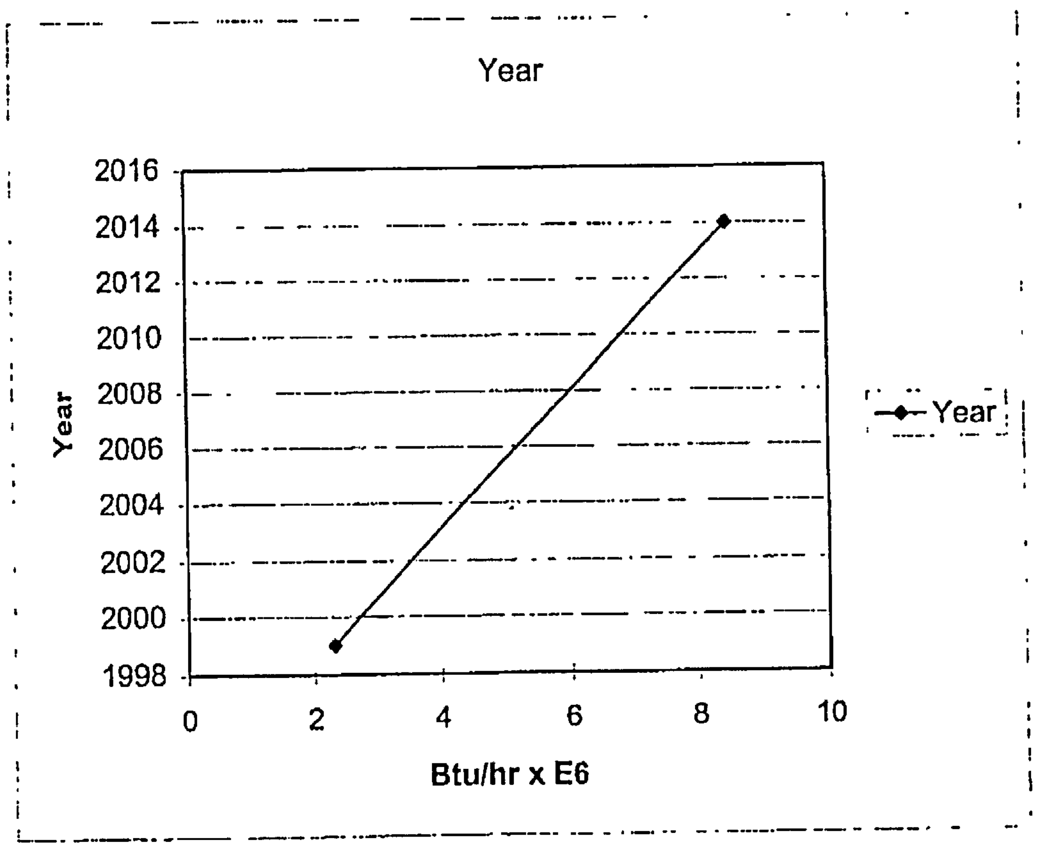
Contribution of Heavy Elements U-239 and Np-239

			to	ts	1-EXP	EXP	P/Po	Po	Elem	P
U-239	2.28E-03	0.7	4.47E+07	5.26E+05	1.00E+00	8.4E-113	1.33E-115	61526310	76	6.23E-106
N-239	2.17E-03	0.7	4.47E+07	5.26E+05	1.00E+00	0.166577	2.55E-04	61526310	76	1.19E+06
U-239	2.28E-03	0.7	8.94E+07	5.26E+05	1.00E+00	8.4E-113	1.33E-115	61526310	76	6.23E-106
N-239	2.17E-03	0.7	8.94E+07	5.26E+05	1.00E+00	0.166577	2.55E-04	61526310	76	1.19E+06
U-239	2.28E-03	0.7	1.34E+08	5.26E+05	1.00E+00	8.4E-113	1.33E-115	61526310	41	3.36E-106
N-239	2.17E-03	0.7	1.34E+08	5.26E+05	1.00E+00	0.166577	2.55E-04	61526310	41	6.43E+05
										3.03E+06

SFP Background Heat

Unit 1	1R13	1R14	1R15	1R16	1R17	1R18	1R19	1R20	1R21	1R22	1R23
Unit 1	Oct-99	Apr-01	Oct-02	Apr-04	Oct-05	Apr-07	Oct-08	Apr-10	Oct-11	Apr-13	Oct-14
Unit 2	2R10	2R11	2R12	2R13	2R14	2R15	2R16	2R17	2R18	2R19	2R20
Unit 2	Apr-99	Oct-00	Apr-02	Oct-03	Apr-05	Oct-06	Apr-08	Oct-10	Apr-11	Oct-12	Apr-14

Btu/hr	Year
2.31E+00	1999
8.46E+00	2014



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Deleware River Temperature Data

Weekly Averages compiled into Specified Era Averages 1967 - 1997

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1967 - 1969	40.0	36.7	37.6	45.8	53.7	62.4	70.4	74.1	72.4	66.6	56.6	47.4
1970 - 1979	39.2	36.0	41.0	47.9	57.3	64.8	72.2	75.0	73.1	64.5	56.2	47.0
1980 - 1989	33.6	34.6	41.4	52.8	63.1	72.1	77.6	76.9	72.5	60.6	49.7	39.9
1990 - 1997	35.0	35.4	41.2	51.6	62.2	70.9	76.8	75.3	70.5	60.3	48.4	41.0
AVERAGE	37.0	35.7	40.3	49.5	59.1	67.5	74.2	75.3	72.1	63.0	52.7	43.8

1967 - 1969	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	42.3	39.5	39.1	44.8	49.9	58.7	68.4	72.6	70.7	65.6	56.7	47.9
	38.2	33.1	36.1	47.3	53.3	61.2	71.3	74.6	72.8	67.3	57.7	48
	37.2	35.7	35.8	46.5	55.5	64.5	72	75.1	75.2	68.6	59	49.4
	44.1	38.8	38.5	41.7	51.2	61.9	65.4	72.8	70.2	68.1	53.5	46.7
	42.7	35	36.1	43.3	55	63.1	67.8	75.3	71.9	70.3	55	45.1
	40.3	35.4	37.6	41.1	57.9	66.2	69.8	75.2	73.9	71	56.6	47.1
	43.2	40.7	37.7	43	48.6	55.1	67	72.5	71.5	66.8	59.6	49
	39.5	37.7	35.1	45.3	51.4	58.2	69.2	74.6	73.6	67.9	61.3	51.7
	38.2	36.5	35.8	44.1	53.6	62.5	70.4	74.5	76	70.1	61	51
	42.3	37.2	39.4	46.1	52.4	64.1	70.2	72.3	69	63.7	51.3	45.2
	37.7	34.7	40.3	46.8	55.9	65.5	72.9	74.7	71.8	65.9	53.2	43.1
	37.5	35.7	39.3	48.6	60.2	68	72.5	75.4	72.2	65.6	54.5	44.3
	41.9			47.5			71.6			61.9		
	37.6			49.9			73.5			63		
1967 - 1969	37			51.2			73.6			63.3		
AVERAGE	39.98	36.67	37.57	45.81	53.74	62.42	70.37	74.13	72.40	66.61	56.62	47.38

Deleware River Temperature Data

Weekly Averages compiled into Specified Era Averages 1967 - 1997

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	37.4	36	37	43.5	53.7	63.2	70.8	75.4	75.3	70.6	61.9	51.6
	40.7	35.7	39.1	44.8	51.8	61.2	70.9	74.3	75.3	69.4	59.2	49.8
	46.5	41.5	41	45	52.9	60.7	69.8	73	75.3	65.8	62.7	53.2
	42.7	40.4	43	48.4	55.5	65.7	73.8	77.4	75	69	60.3	51.9
	42.9	40.4	42.6	48.1	56.2	64.3	71.3	73.4	73.7	65.3	58.7	50.7
	44.4	40.7	41	43.5	53.8	61.9	70.6	74.5	73.4	66.5	55.9	48.1
	41.2	37.9	42.2	48.5	55.5	61.3	70.3	73.1	76.5	55.2	59	52.7
	28.2	28.6	46	56.3	62.5	65.2	78.1	77.5	74.5	54.4	57.6	49.2
	29.8	26.8	32.8	50.2	55.9	69.7	74.4	78.1	73.7	58.6	58.7	49.5
	31.4	24.7	38.8	49	64.7	70.2	75.5	73.2	73.3	57.3	56.2	48.3
	42.1	36.1	37.5	40.2	56.3	64.9	68.1	75.8	72.3	73.6	61.6	52.8
	44.4	36.5	40.1	41.3	54	63.1	68.1	74.7	71.2	72.5	59.7	50.4
	49.4	40.4	41.8	42.5	54.9	62.8	65.7	73.2	72.5	70.7	54.1	46.1
	46.6	39.3	43.5	46.1	56.4	67.1	71	76.5	72.2	72.4	52.1	44.6
	45.3	40.7	42.9	44.5	58.7	66.1	68.4	74.1	71.6	69.1	51.3	35.8
	45.2	41.1	42.1	42.4	55.1	54.8	67.8	74.6	70.2	68.9	47.9	36.8
	45.6	39.9	42.9	46.1	56.6	64.3	68.8	73.3	71.7	69.1	52.5	42.4
	37.2	30.7	46.3	50.8	67.1	58.8	73.6	74.6	70.8	64.6	50.1	39.4
	33	27.2	38.1	45.8	61.4	70.3	71.6	77.8	73.2	65.2	50.6	44.2
	35.9	23.9	42.7	48.5	65.4	71	70.2	72.6	70.3	66.3	50	39.8
	39.1	36	36.7	42	50.7	61.3	69.5	74.4	75.9	72.7	63.3	54.3
	42.5	35.8	36.1	43	49.5	58.7	69.7	73.7	74.6	70.7	65.6	53.9
	48.4	42.2	41.2	43.1	50.8	59.2	67	73.1	74.3	66.3	60.7	51.8
1970 - 1979	43.7	42.2	40.7	46.8	54	61.7	72.6	76.8	78.2	71.4	61.4	55.1
	44.5	41.5	42.6	45.9	53.2	61.7	70.3	73	74.3	67.2	61.1	50.9
	45.9	41.9	41.2	42.1	49	60.2	69.1	74.3	73.4	67.5	63.5	55.1
	43.1	37.4	42.4	46.7	53.7	58.9	69.8	72.4	73.1	67.7	57	48
	32.9	25.4	40.6	51.6	61	65.3	75.3	77.8	75.7	60.4	56.2	41.2
	31.6	26.7	28.6	46.7	53.5	69.2	73.1	76.6	75.7	61.6	53.8	44.7
	33.5	29.6	36.2	47.3	61.8	69	71.8	79.1	75.8	60.4	52.9	46.3
	35.7	36.2	38.9	45.5	58.6	66.5	71.9	76.2	75.7	68.4	56.4	47.4
	39.2	37.9	40	46.5	55.8	66	71.9	74.3	73.5	68.2	56.6	50.7
	45.8	40.4	41.8	46.7	56.7	64	72.5	74.4	72	63.2	53.5	47.2
	42.6	39.3	44.4	50.9	58.2	68.9	74.7	77.3	73.2	67.1	56.8	47.4
	42.8	40.6	43	50	60	66.6	71.6	75	71.6	62.3	53.4	47.4
	43.4	41.8	42.6	45.6	58	66.7	72.3	74.7	70	65.7	57.4	47.5
	39.1	41.3	44.9	51.3	57.5	67.1	71.2	74	71	62.2	50.4	42.5
	26.2	36.9	46.9	60	68.2	71.1	76.1	74.9	67.7	53.3	43.8	35.6
	29.9	28.5	42	50.9	66	72.5	76.9	76.9	68.1	56.7	54.1	37.4
	32.9	30.1	46	53.4	66.4	70.5	77.2	75	66.7	57.8	51	39.5
	36			46.3			73.6			65.7		
	36.8			47.7			73			68		
	44.3			48.4			72.9			62		
	42.3			52.3			75.8			64.9		
	43.4			52.3			72.6			61.7		
	43			47			73.9			64.2		
	36.5			52			72			59.4		
	25.3			61.2			75.2			54.1		
	28.5			51.6			75.6			54.8		
1970 - 1979	33.5			56.8			79.8			54.6		
AVERAGE	39.25	36.01	40.96	47.94	57.28	64.79	72.15	75.03	73.06	64.49	56.23	47.03

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Deleware River Temperature Data

Weekly Averages compiled into Specified Era Averages 1967 - 1997

1980 - 1989	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	37.1	30.3	36.5	52.3	62 3	67.7	77	76 3	74.9	60.3	46.6	40.4
	25.6	32.4	40.6	54.7	64.5	68.3	77.9	75	72.9	55.6	43.2	37
	26.7	33.5	41	50.6	61.2	71.7	80.7	76.7	71.5	60.5	48 6	37.3
	33.3	39.9	39.7	49.8	62.8	74.1	77.8	76 8	69.2	60.2	46.3	34.8
	36	31.8	40 6	56.3	63 8	68.4	78.1	78 8	72.5	63.5	51.1	44.8
	32.4	34 6	43.1	52.3	65.4	71	77.1	76.3	70.9	60.7	49.4	41.6
	37.7	35 9	36	54 2	58 3	74.2	79	76.7	72.4	59.8	52.6	41.5
	30.7	40.5	39.1	51.1	51.8	74.5	79.5	78.7	70.2	59	46.5	42.7
	36	32.2	46.3	53.4	66.7	70.8	77.6	83.9	73.8	61.9	54 4	42.3
	37.7	36	45.3	46	67.4	71.6	73.8	76.7	70.3	67.2	53	37.7
	30.3	31.4	40.8	51.8	63.2	74	74.3	72.7	69.4	61.6	56.6	42.4
	36 3	33 3	44.9	45.8	67.5	73.7	74.7	74.9	66.9	66 5	47.1	40.5
	42.4	32.5	39	43.4	62.6	72.9	76	77	73.5	62.1	49.5	43.2
	43.5	32.5	41.6	50.5	64	75 8	73.1	75.9	72.8	67.2	47.1	41.4
	33.9	33 9	42.9	52.7	60.9	67.8	73.7	74.5	73.1	70	50.6	41
	38.2	35.1	41.8	49.1	63.9	73.3	76.6	77 7	70.9	66.3	49.4	37.3
	36.9	37	37.9	51.2	59.5	73.1	73	80 2	76	67.5	54.7	35.8
	36 7	37.3	42.4	50.9	64.5	74.9	78	76.4	73.9	66 1	49.5	31
	35.3	29 6	33	50.6	60	68.8	74.7	80.1	77 6	63 5	50.2	40.5
	26.7	30 5	41.2	54.6	58 8	69 8	77.7	76.6	71.8	57.7	52.3	41.5
	32.6	30.5	36.2	43.9	60 5	68.8	77.5	79	71.9	65.8	53.7	49.3
	38.1	31.5	37.7	46.7	57.3	67.3	75.9	78 5	74.6	60.2	56.3	43.8
	38.6	29.8	43.9	51.4	63.9	70 6	75.7	77.4	76.1	64.3	54.3	44.1
	32.7	33	34 5	51.7	60.6	72.3	75.9	78.7	69.8	65.1	54.3	44.1
	37.4	33.2	36 7	51.6	59	71.8	78 9	79.3	72.4	62	53.3	43.5
	32.1	34.2	40	51.9	56.5	67.1	76.3	83	76.3	62.7	51.4	45
	35 3	38	36	51	57.6	72.8	79.1	78.5	74.9	61.9	56.2	39.5
	35.8	32.5	43	55.3	66.1	71	78.5	76.4	71.1	57.7	42.2	32.4
	28.5	42.6	44	54.9	67.4	74.3	76.9	72.5	64.7	54.6	42.9	34.9
	24.9	35	44.4	54.4	67.9	73.8	80.8	72.5	97.3	54 9	47.1	43.4
	30 4	40.1	41	51	65.7	74.6	77.3	76.1	68.9	62.4	45	42.7
	28 9	41.8	47.4	61.3	69.3	71.9	78	74.9	69.3	60.9	49 2	34.2
	34.9	33.4	48.7	53 5	70.2	73.4	78.6	71	68.4	58.7	46	39.9
	34.2	35.1	47.4	56 4	68.5	75.8	81.6	74.3	70.1	57.5	45.5	41.2
	32.1	37.1	47.1	51.7	66 9	74.6	79 8	76 5	69.5	56.5	47.9	38.1
	36.4	36.3	47.1	55	66.5	77.4	79.9	77	69.9	58.3	44.3	26.8
	32			56.4			78.7			52.2		
	30.7			57.5			76.1			54.2		
	27.1			57.6			80.1			54.5		
	31.1			54.9			76.4			63.2		
	29.6			62			77.7			56.6		
	32.3			57.4			79.2			57.2		
	31.6			56			80.3			55.1		
	33.5			53 2			81.7			52.7		
1980 - 1989	36.9			57.4			78 9			58.5		
AVERAGE	33.58	34.56	41.36	52.79	63.14	72.05	77.56	76.88	72.49	60 55	49 68	39.93

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Deleware River Temperature Data

Weekly Averages compiled into Specified Era Averages 1967 - 1997

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	34.3	43.8	47.3	52	63.4	68.8	76.1	78 5	74 6	67.5	49.8	44
	39	44.8	51	54 5	63.1	71.7	79.1	75 1	70.3	60.1	47.4	44.3
	38 1	36 8	43 3	50 3	67.6	76.7	78.7	77.2	75.3	60.6	49.6	46.3
	39.3	39.9	45.2	52 3	70.9	77.4	80.3	77.4	74.1	59.8	52.2	41.6
	28.7	35.3	43.2	56.3	61.1	71.1	81.7	75.9	74	60 1	53 9	41.6
	41.8	38.7	40.9	52.4	63.9	71.5	82.2	74.9	73.1	65 1	49	41.6
	29.7	36.6	36.5	50.7	66.8	72.3	80.4	78.2	75.9	60.7	51.3	44.7
	32.9	34.8	35.9	51.1	66.9	75.6	79.7	78	71.9	62.4	48 3	42.8
	29	29.6	38.1	48.4	61.3	72.7	75.8	77.5	70.3	66 8	47	45.1
	42	32.9	40 3	50.1	63.1	77.1	77.7	76.2	70.2	67.6	49.9	42.6
	40.5	31.1	41 2	44.4	62.8	74.1	73.7	82.1	74.5	63 9	47.6	37.3
	41	33.6	45.9	44.5	67.5	75.7	78.3	79 5	71.9	64.7	51.5	34.6
	34.9	31.7	37.4	46.1	60.7	74	79.2	78.5	77.4	65.1	52.1	43.3
	39.7	33.6	40.4	48.1	66.9	77.3	77.2	79	73	68	45.7	42.4
	31.1	35.6	44.6	45.4	59.3	68.3	76.4	77.8	71.6	67	49 9	40.3
	41.3	41.3	41	50.1	61.4	67.2	77.5	76.6	76	65.5	55.9	45.9
	31.7	39.7	44.6	49.7	62.5	76.2	75.1	77.5	76.1	68.5	50.6	47.2
	39	35.1	42.7	55	58 1	67.7	77.8	77.5	74.3	64.2	51.9	45 1
	41.3	36 4	36.7	48.1	63 4	68.5	75.9	77.5	80.1	62.2	52	47.9
	40 7	29.4	35.6	47.5	60.9	69.3	82.7	78.5	72.4	62	56.6	47.8
	33.1	32 5	37.5	51.7	59 6	74	81.2	82 1	76.6	62.5	54.3	42.7
	37.4	30.5	37.5	49.7	62	68.5	78.7	79 9	78.6	68.4	55.5	45.4
	28.1	35.8	45.4	46.5	57.6	63 5	79.7	76.7	72.6	62.3	52.5	42.1
	38 6	41.9	49	50.7	63 8	74.2	77.8	76	67.6	66.7	47.6	43.9
	37.3	41.3	48	57.6	76 7	78	78	78.3	69 3	63	48.7	39.5
	37.2	40.4	42.3	55 3	64 3	71.3	80.2	76 1	68 3	58.7	48.9	39 8
	35.7	33.9	40.8	55.1	68 2	76 5	78	80.1	68.9	55.8	49	39
	39.6	33 4	44.2	54.2	66.1	78	78.3	75 9	68 8	59.2	48	43.1
	26.5	35.3	47.4	58 8	70 2	75.6	81.5	77.5	68.1	59.4	43.9	31.8
	40 3	38 8	43	56 2	66.3	77.4	84	79.6	70.3	62.9	47.2	40.8
	32.3	45	47.9	58	63.3	76.5	78.5	74.4	67.9	59 6	44.4	39.3
	32.9	40.2	44.7	52.6	61.3	72.3	76.2	75.4	71.4	56.8	46.2	39.5
	39.7			60.9			77			57.4		
	37.2			59.2			78.5			56 6		
	35 4			57.7			77.5			53 6		
	38			58.1			78.5			55 3		
	26.5			61.2			81			57.7		
	37.8			57.9			84 6			60.1		
	33.3			61.3			78 3			58.6		
1990 - 1997	34 1			56.8			76.7			54.4		
AVERAGE	35.05	35.45	41.20	51.62	62.15	70.88	76 82	75.32	70.47	60.26	48.44	41.01

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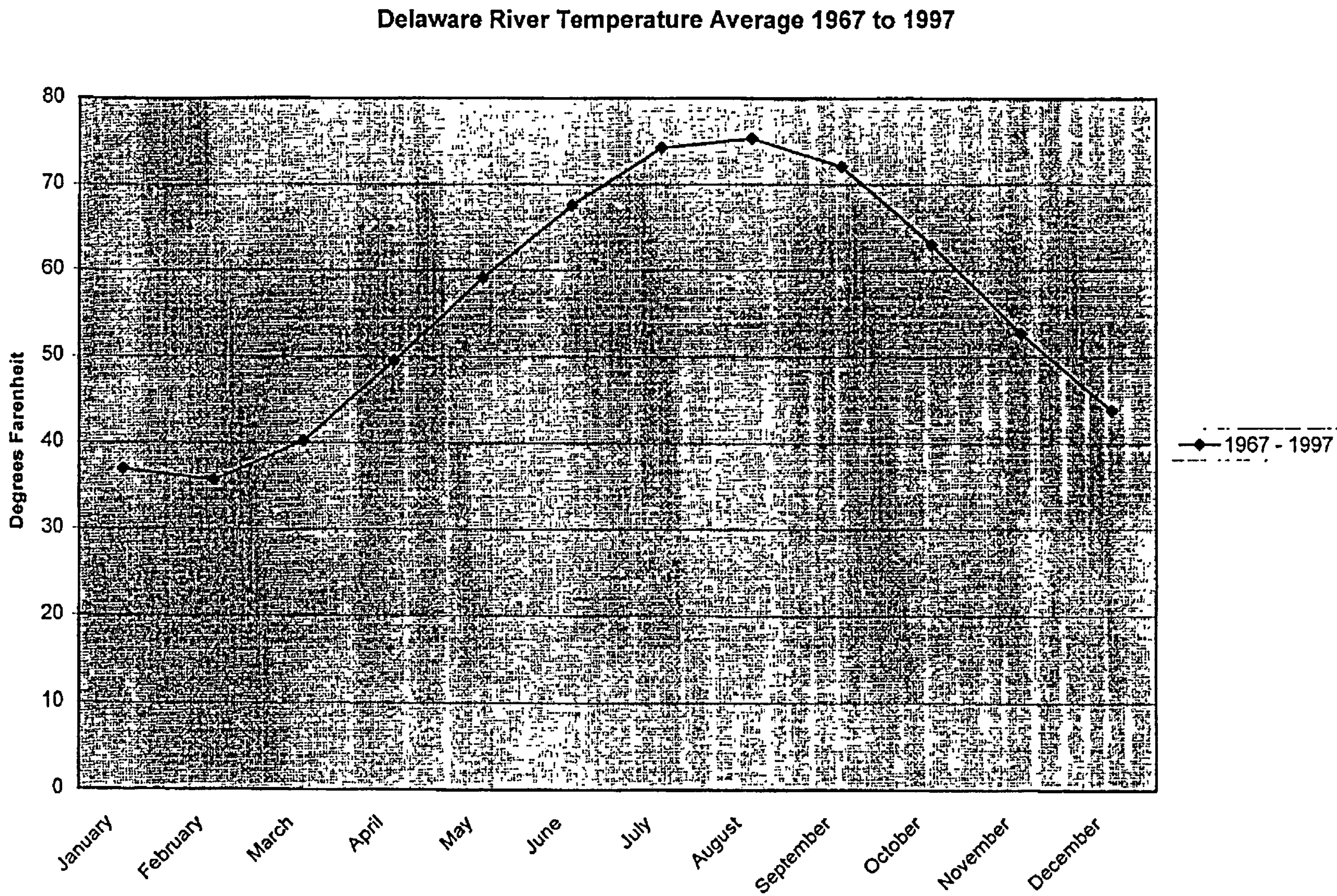

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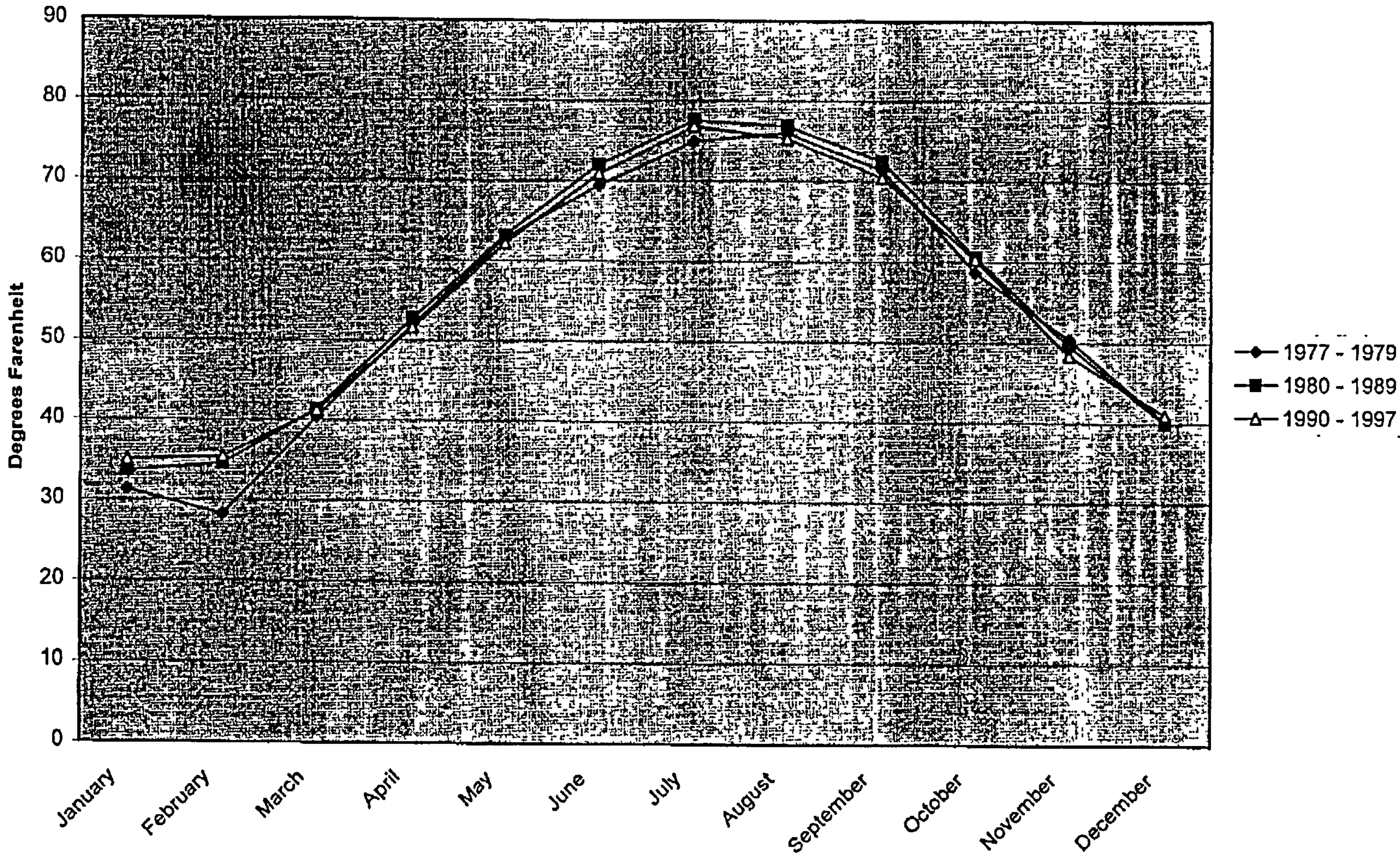
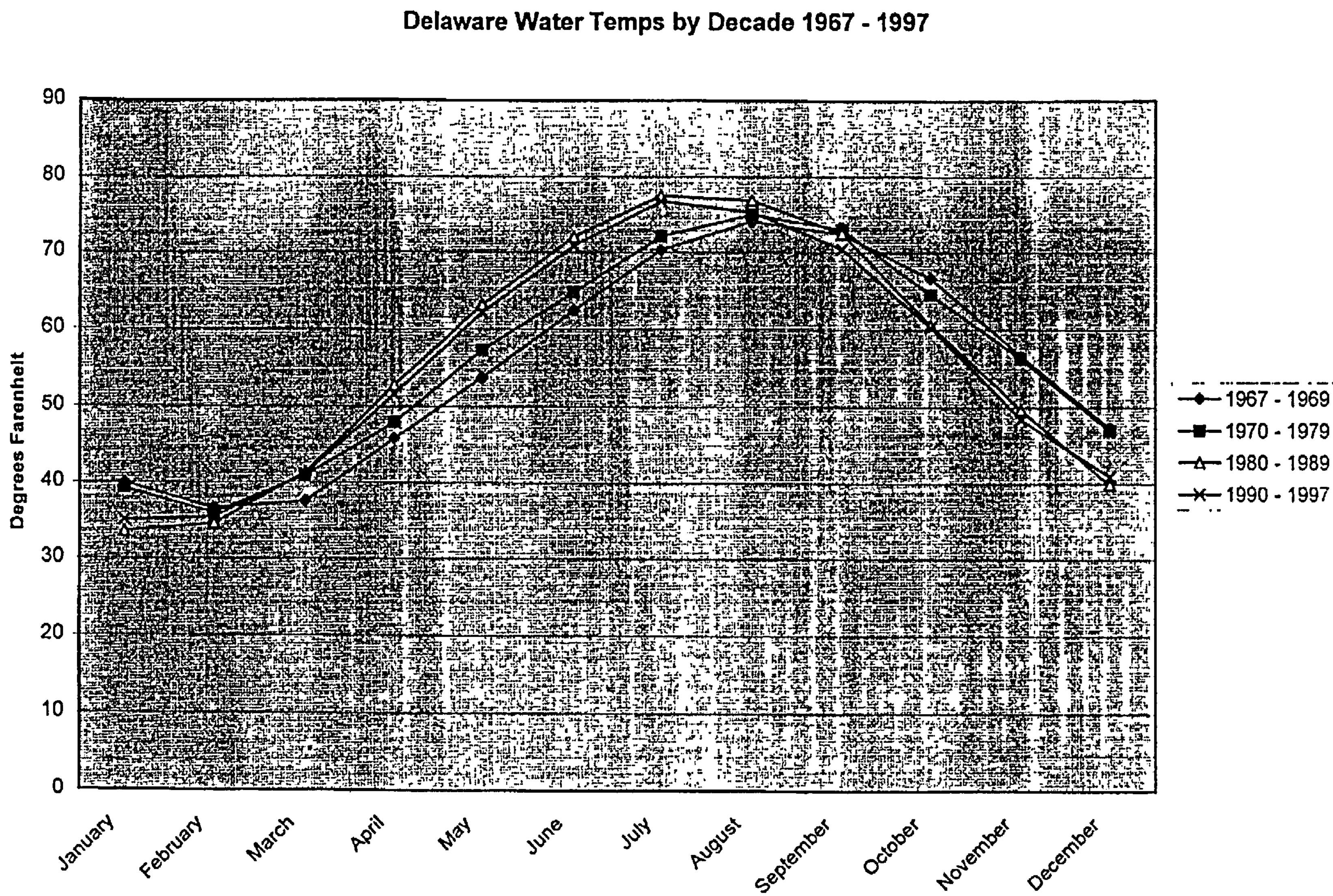
Delaware River Average Temperatures for Past 20 years (1977 - 1997)





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Comparison of Reedy Island and PSEG Maximum Annual Temperatures

Year	Maximum Annual Temperature at Reedy Island (°F)	Actual Maximum Annual Temperature from HC.A2438	Temperature Difference Between HC.A2438 and Reedy Island
1992	78.7	81.8	3.1
1993	82.7	85.5	2.8
1994	81.7	86.4	4.7
1995	84.6	85.4	0.8
1996	80.4	82.0	1.6
1997	79.7	84.6	4.9
Average	81.3	84.3	3

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	HTC-STX	Version 3 6	Time. 9.01:16 AM	Date: 4/30/02	File	Spfchx
	*** Main ***					English units
1	Job No		Item No.	EVALUATION Case		
2	Case Desciption	SFPHX				
3	TEMA Type	BEU - HORZ	Shell/Unit 1	Conn In	1 Series	1 Parallel
4	Size:	33 500 in Dia	146.3 in Tube Length		in	Kettle Dia
5	Surface/Shell ft²	2,353.2	Gross	2,319 3 Eff 151		U-Bend Area
6	Surface/Unit ft²	2,353.2	Gross	2,319 3 Eff 151		U-Bend Area

	Performance of One Unit		**SHELLSIDE**	**TUBESIDE**
7	Fluid Circulated			SFPHX
8	Total Fluid In	lb/hr	1,490,000 0	1,140,000.0
9	Vapor	lb/hr	0.0	0 0
10	Liquid	lb/hr	1,490,000 0	1,140,000 0
11	Fluid Vap'z/Cond	lb/hr	0 0	0 0
12	Density In/Out	lb/ft³	62 050 / 61 946	61 729 / 61.841
13	Spec. Heat Vap/Liq	Btu/lb-F	0.000 / 0 997	0 000 / 0.997
14	Viscosity Vap/Liq	cP	0 000 / 0 692	0 000 / 0.588
15	Therm Cond Vap/Liq	Btu/hr-ft-F	0 000 / 0 364	0 000 / 0.370
16	Temperature In/Out	°F	95.0 / 103.0	120.0 / 109 54
17	Operating Pressure (Abs)	psi	75 000	50.000
18	Press. Drop Allow/Calc	psi	9 000 / 10.981	15.000 / 18.933
19	Number of Passes/Shell		1	4
20	Velocity, Average	ft/sec	4 07	9 61
21	Film Coef	Btu/hr-ft²-F	1912 81	2256 37
22	Fouling Resist	hr-ft²-F/Btu	0 000500	0 000575

23	Heat Duty	11,883,525 Btu/hr	MTD/Wtd/Corr		14.81 °F	F-CORR	0 941	
24	Transfer Rate	345.99	Serv	372 11 Calc	655.32	Clean	0 00136	Foul

	Construction of One Shell					
25	TEMA Shell Type		E	Rear End Type		U.T.
26	Tube Type		PLAIN	Bundle Dia	in	32.50
27	Tube O D	in	0.750	No. Holes/TubeSheet		920
28	Tube I D	in	0 652	No. Holes Counted		
29	Area Ratio		1.150	Tube Pitch	in	0.9375
30	Tube Length Total	ft	12.19	Tube Layout Angle		30
31	Tube Length Effective	ft	12 00	Impingement Plate		NO
32	Baffle Type		VERT-DBL-SEG	Crosspasses/Shell		9
33	Baffle Cut Frac Dia/NFA		0 160/0 200	Central Spacing	in	16 558
34	Window Area	in²	94 9941	In/Out Spacing	in	23 9/4.2
35	Seal Strips		YES	Drop Under Noz In/Out	in	1.7/1.7

	Shell Nozzles		**Inlet**	**Outlet**	**Tube Nozzles**		**Inlet**	**Outlet**
36	Inside Dia,	in	10 00	10 00	Inside Dia,	in	10.00	10 00
37	Velocity	ft/sec	12 23	12.25	Velocity	ft/sec	9.41	9.39
38	Rho-V-Sqr	lb/ft-sec²	9280	9296	Rho-V-Sqr	lb/ft-sec²	5461	5451
39	Nozzles/Shell	(OPP. SIDE)	1	1				

	Shellside Performance			**Pressure Drop**		
40	Bundle Flow Fraction		0.761	Shell Cross/Wind		4 378/4 408
41	Mass Vel Cross/Wind		252.1/627.4	Tubes		17.750
42	Mass Vel Long/Mean		125 5/397.7	Nozzles Shell/Tube		2 195/1 183
	Bundle Diameter Clearances			**Tube Metal Temperatures**		
43	Bundle-Shell	in	1 00000	Avg Tube Metal Temp	°F	106 8
44	Baffle-Shell	in	0 18750	Shellside Avg Surf Temp	°F	102 0
45	Tube-Baffle	in	0 03625	Tubeside Avg Surf Temp	°F	111 6
46	Baffle Thk.	in	0.313			

5-C-SF-MEE-1679 Rev. 0
Attachment C
Page C1

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HTC-STX *** Summary ***	Version 3 6		Time 9 01 16 AM		Date 4/30/02		File Spfchx English units
Item No							
Service	SFPHX						
Calculation Mode	Evaluation Case						
Size	34 x 146	Type	BEU - HORZ	Connections	1 Series		1 Parallel
Surface/Unit	2,319		Shells/unit	1		Surf/Shell	2,319 35
Cost/Unit	42,668		Cost/Surf	18 4		Weight/Shell	9,531
Heat Duty	11,883,525		MTD	14 81		F-corr	0 9409
Rate-Service	345 99		Calculated	372 11		Calc Fouling	0 00136

	Shell	Tubes		
			Tubes	0 750 x 0 049 on 0 9375 30 deg
Flow Rate	1490000	1140000	Tube No	920 Type PLAIN
Temperature In	95 0	120 0	Baffles.	VERT DBL-SEG 16 6 space 20 0 cut
Temperature Out	103 0	109 5		
Pressure Drop	10 981	18 933	Surface Area	OK Over design by 7.55%
Velocity	4.066	9 611	Shell pressure Drop	** Allowable exceeded
Passes	1	4	Tube Pressure Drop	** Allowable exceeded
Film Coef	1912 8	2256 4	Vibration	** Tube vibration likely.
Nozzle In	1 x 10 0	10 0	Shell Nozzles	** Rho-V-Sqr exceeds 4000
Nozzle Out	1 x 10 0	10 0	Chan Nozzles	OK. Rho-V-Sqr within 6000

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SERVICE SPENT FUEL PIT HX		ITEM NO. AH-SF-537	
MFR JOS. OAT & SONS	TYPE BEU	SIZE 33.5 x 142	
NO UNITS	CONN- SHELL (SER) (PARA)	TRANSF. AREA	PER SHELL 2320 SQ. FT.
TOTAL NO SHELLS 1	ECTED TUBES (SER) (PARA)		PER UNIT 2320 SQ. FT.

PERFORMANCE (PER UNIT)

		SHELL SIDE	TUBE SIDE
FLUID		WATER	WATER
TOTAL FLUID ENTERING	LB/HR		
LIQUID	LB/HR	1.49 x 10⁶	1.14 x 10⁶
VAPOR	LB/HR		
NON-CONDENSIBLES	LB/HR		
STEAM	LB/HR		
FLUID VAPORIZED OR CONDENSED			
GRAVITY-LIQUID		@ °F.	@ °F.
VISCOSITY-LIQUID CENTIPOISES		@ °F.	@ °F.
MOLECULAR WEIGHT-VAPORS			
TEMPERATURE IN. °F.		95.0	120.0
TEMPERATURE OUT. °F.		103.0	109.5
PRESSURE @ INLET. PSIG.			4
NUMBER OF PASSES		1	9.4
VELOCITY. FT/SEC.		4.1	15
PRESSURE DROP. CLEAN PSI.		9	1.15X.0005=.000575
FOULING FACTOR - REQ.		.0005	

HEAT EXCHANGED - BTU/HR 11.44 x 10⁶ LOG MTD. °F. 15.7 CORRECTED MTD. °F 14.75

TRANSFER RATE - SERVICE 340 CLEAN 558 FOULING FACTOR .001075

CONSTRUCTION

	SHELL SIDE	TUBE SIDE
DESIGN PRESSURE - PSIG.	150	150
TEST PRESSURE - PSIG.		
DESIGN TEMPERATURE - °F.	230	200

TUBES - NO. 460 O.D. 3/4 BWG 18 LENGTH 26'-0" AV. L, PITCH 15/16 □ △ ◇

SHELL 33 1/2 I.D. O.D.

CONNECTIONS - SHELL | IN - 10 IN. B.W. FACING | OUT - 10 IN. B.W. LB. FACING

CHANNEL | IN - 10 IN. 150 LB. RF FACING | OUT - 10 IN. 150 LB. RF FACING

IMPINGE. (YES)(NO) IN THE

BAFFLES | CROSS DBL - SEG. SPACING 12" IN. | LONG. (PERM)(REMOV)(PACKED)

CODE REQUIREMENTS - ASME TUBES III-C/SHELL VIII TEMA CLASS R CUST. SPEC.

WT - LBS - EA. SHELL & BUNDLE 11 120 LBS. FULL OF WATER 19 100 LBS BUNDLE 7130 LBS

STRESS - RELIEVED PARTS MARKED SR RADIOGRAPHED MARKED XR

PART	MATERIAL	THICK.	CORR. ALL.	PART	MATERIAL	THICK.	CORR. ALL.
TUBES	SA 213 TP 304	.046		FLOAT. T.S.			
SHELL	SA 285C	.438	.125	FIXED T.S.	SA 240 TP 304	2.25	0
SHELL COVER	SA 285C	.438	.125	TUBE SUPPORTS			
CHANNEL	SA 240 TP 304	.250	0	CROSS BAFFLE	C. ST.	.625	
CHAN. COVER	SA 240 TP 304	.250	0	LONG BAFFLE			
NOZZ. NO. COVER				GASKETS	SPIRAL WOUND		

AV. WALL

REMARKS-

BA-19 3/61

NO	DATE	REVISIONS			JOB NO.	DRWG. NO.
1	1/?/??	..21D				
					SHEET 1	OF 1

GREEN OAT & SONS, INCORPORATED

5-C-SF-MEE-1079 REV.0

Attachment C
Page C3

OUTSTANDING CHANGES MUST BE ATTACHED FOR WORKING COPY
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HTC-STX *** Summary ***	Version 3 6		Time. 2 12 11 PM		Date 6/12/2002		File: sfphx-71ccw6%-158 English units
Item No							
Service	SFPHX-71CCinlet						
Calculation Mode	Rating Case						
Size	34 x 148	Type	BEU - HORZ	Connections	1 Series		1 Parallel
Surface/Unit	2,179		Shells/unit	1		Surf/Shell	2,179 24
Cost/Unit	41,206		Cost/Surf	18 91		Weight/Shell	9,236
Heat Duty	43,968,300		MTD	54 41		F-corr	0 9456
Rate-Service	370.84		Calculated	356.37		Calc Fouling	0.00105

	Shell	Tubes		
	Shell	Tubes	Tubes	0 750 x 0 049 on 0 9375 30 deg
Flow Rate	1501800	1222716	Tube No	866 Type PLAIN
Temperature In	71.0	160 9	Baffles·	VERT DBL-SEG 16 5 space 22 0 cut
Temperature Out	100 1	125 4		
Pressure Drop	10 413	4 458	Surface Area	** Under design by -3 91%
Velocity	4 215	5 642	Shell pressure Drop	** Allowable exceeded
Passes	1	2	Tube Pressure Drop	OK Within allowable
Film Coef	2047.0	1730 5	Vibration	** Tube vibration likely.
Nozzle In	1 x 10 0	10 0	Shell Nozzles	** Rho-V-Sqr exceeds 4000
Nozzle Out	1 x 10 0	10 0	Chan Nozzles	** Rho-V-Sqr exceeds 6000

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HTC-STX	Version 3.6	Time 2 44 21 PM		Date 6/12/2002	File·	
*** Summary ***						English units
Item No						
Service	SFPHX-71CCinlet					
Calculation Mode	Rating Case					
Size	34 x 146	Type	BEU - HORZ	Connections	1 Series	1 Parallel
Surface/Unit	2,179		Shells/unit	1	Surf/Shell	2,179 24
Cost/Unit	41,206		Cost/Surf	18 91	Weight/Shell	9,236
Heat Duty	21,997,584		MTD	32 63	F-corr	0.9371
Rate-Service	309.38		Calculated	297.09	Calc Fouling	0.00103

	Shell	Tubes			
Flow Rate	1501800	742640	Tubes	0 750 x 0 049 on 0 9375 30 deg	
Temperature In	71 0	128 4	Tube No	866 Type·	PLAIN
Temperature Out	85 6	98.9	Baffles·	VERT DBL-SEG 16 5 space 22 0 cut	
Pressure Drop	10 441	1 783	Surface Area	** Under design by -3 97%	
Velocity	4.185	3 349	Shell pressure Drop	** Allowable exceeded	
Passes	1	2	Tube Pressure Drop	OK Within allowable	
Film Coef	1944 2	963 4	Vibration	** Tube vibration likely	
Nozzle In	1 x 10 0	10 0	Shell Nozzles	** Rho-V-Sqr exceeds 4000	
Nozzle Out	1 x 10 0	10 0	Chan Nozzles	OK. Rho-V-Sqr within 6000	

S-C-SF-MEE-1679 REV. 0

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HTC-STX	Version 3 6		Time: 1 55 50 PM		Date 6/12/2002		File:
*** Summary ***							English units
Item No							
Service	SFPHX-71CCInlet						
Calculation Mode	Rating Case						
Size	34 x 146	Type	BEU - HORZ	Connections	1 Series		1 Parallel
Surface/Unit	2,179		Shells/unit	1		Surf/Shell	2,179 24
Cost/Unit	41,206		Cost/Surf	18 91		Weight/Shell	9,236
Heat Duty	42,971,104		MTD	54 37		F-corr	0 9478
Rate-Service	362.65		Calculated	356.01		Calc Fouling	0.00111

	Shell	Tubes		
			Tubes	0 750 x 0 049 on 0 9375 30 deg
Flow Rate	1501800	1222716	Tube No	866 Type: PLAIN
Temperature In	71 0	160 0	Baffles:	VERT DBL-SEG 16 5 space 22 0 cut
Temperature Out	99 5	125 3		
Pressure Drop	10 412	4.459	Surface Area	OK Over design by -1 84%
Velocity	4 214	5 640	Shell pressure Drop	** Allowable exceeded
Passes	1	2	Tube Pressure Drop	OK Within allowable
Film Coef	2043 5	1725 7	Vibration	** Tube vibration likely
Nozzle In	1 x 10 0	10 0	Shell Nozzles	** Rho-V-Sqr exceeds 4000
Nozzle Out	1 x 10 0	10 0	Chan Nozzles	** Rho-V-Sqr exceeds 6000

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HTC-STX *** Summary ***	Version 3 6		Time: 1:49 54 PM	Date 6/12/2002		File: sfphx-71ccw6%-170 English units	
Item No							
Service	SFPHX-71CCInlet						
Calculation Mode	Rating Case						
Size	34 x 146	Type	BEU - HORZ	Connections	1 Series		1 Parallel
Surface/Unit	2,179		Shells/unit	1		Surf/Shell	2,179 24
Cost/Unit	41,206		Cost/Surf	18 91		Weight/Shell	9,236
Heat Duty	47,964,360		MTD	60 30		F-corr	0 9471
Rate-Service	365.01		Calculated	360.3		Calc Fouling	0.00113

	Shell	Tubes		
			Tubes	0.750 x 0.049 on 0.9375 30 deg
Flow Rate	1501800	1217710	Tube No	866 Type: PLAIN
Temperature In	71 0	170 0	Baffles:	VERT DBL-SEG 16 5 space 22 0 cut
Temperature Out	102 7	131 2		
Pressure Drop	10 407	4 410	Surface Area	OK Over design by -1 3%
Velocity	4 221	5 652	Shell pressure Drop	** Allowable exceeded
Passes	1	2	Tube Pressure Drop	OK Within allowable.
Film Coef	2065 9	1796 3	Vibration	** Tube vibration likely
Nozzle In	1 x 10 0	10 0	Shell Nozzles	** Rho-V-Sqr exceeds 4000
Nozzle Out	1 x 10 0	10 0	Chan Nozzles	** Rho-V-Sqr exceeds 6000

S-C-SF-MEE-1674 REV-0

HTC-STX	Version 3 6	Time 1 43 40 PM		Date. 6/12/2002		File sfphx-71ccw6%	
*** Summary ***						English units	
Item No							
Service	SFPHX-71CCinlet						
Calculation Mode	Rating Case						
Size	34 x 146	Type	BEU - HORZ	Connections	1 Series		1 Parallel
Surface/Unit	2,179		Shells/unit	1		Surf/Shell	2,179 24
Cost/Unit	41,206		Cost/Surf	18 91		Weight/Shell	9,236
Heat Duty	53,116,176		MTD	66 10		F-corr	0 9461
Rate-Service	368.76		Calculated	364.51		Calc Fouling	0.00113

	Shell	Tubes		
			Tubes	0 750 x 0 049 on 0 9375 30 deg
Flow Rate	1501800	1213955	Tube No	866 Type' PLAIN
Temperature In	71 0	180 0	Baffles·	VERT DBL-SEG 16 5 space 22 0 cut
Temperature Out	106 1	137.0		
Pressure Drop	10 402	4 372	Surface Area	OK Over design by -1 16%
Velocity	4 228	5 671	Shell pressure Drop	** Allowable exceeded
Passes	1	2	Tube Pressure Drop	OK Within allowable
Film Coef	2088 7	1873 2	Vibration	** Tube vibration likely
Nozzle In	1 x 10 0	10 0	Shell Nozzles	** Rho-V-Sqr exceeds 4000
Nozzle Out	1 x 10 0	10 0	Chan Nozzles	** Rho-V-Sqr exceeds 6000

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HTC-STX	Version 3 6	Time. 4.01.40 PM		Date 6/12/2002		File. sfphx-71ccw6%-135
*** Summary ***						English units
Item No						
Service	SFPHX-71CCInlet					
Calculation Mode	Rating Case					
Size	34 x 146	Type	BEU - HORZ	Connections	1 Series	1 Parallel
Surface/Unit	2,179		Shells/unit	1	Surf/Shell	2,179.24
Cost/Unit	41,206		Cost/Surf	18 91	Weight/Shell	9,236
Heat Duty	30,407,960		MTD	39 57	F-corr	0 9505
Rate-Service	352.63		Calculated	344.49	Calc Fouling	0.00109

	Shell	Tubes		
	Shell	**Tubes**	Tubes	0 750 x 0 049 on 0 9375 30 deg
Flow Rate	1501800	1232728	Tube No	866 Type PLAIN
Temperature In	71 0	135 0	Baffles·	VERT DBL-SEG 16 5 space 22 0 cut
Temperature Out	91 2	110 5		
Pressure Drop	10 428	4 576	Surface Area	** Under design by -2 31%
Velocity	4 197	5 598	Shell pressure Drop	** Allowable exceeded
Passes	1	2	Tube Pressure Drop	OK. Within allowable
Film Coef	1986 9	1547.3	Vibration	** Tube vibration likely
Nozzle In	1 x 10 0	10 0	Shell Nozzles	** Rho-V-Sqr exceeds 4000
Nozzle Out	1 x 10.0	10.0	Chan Nozzles	** Rho-V-Sqr exceeds 6000

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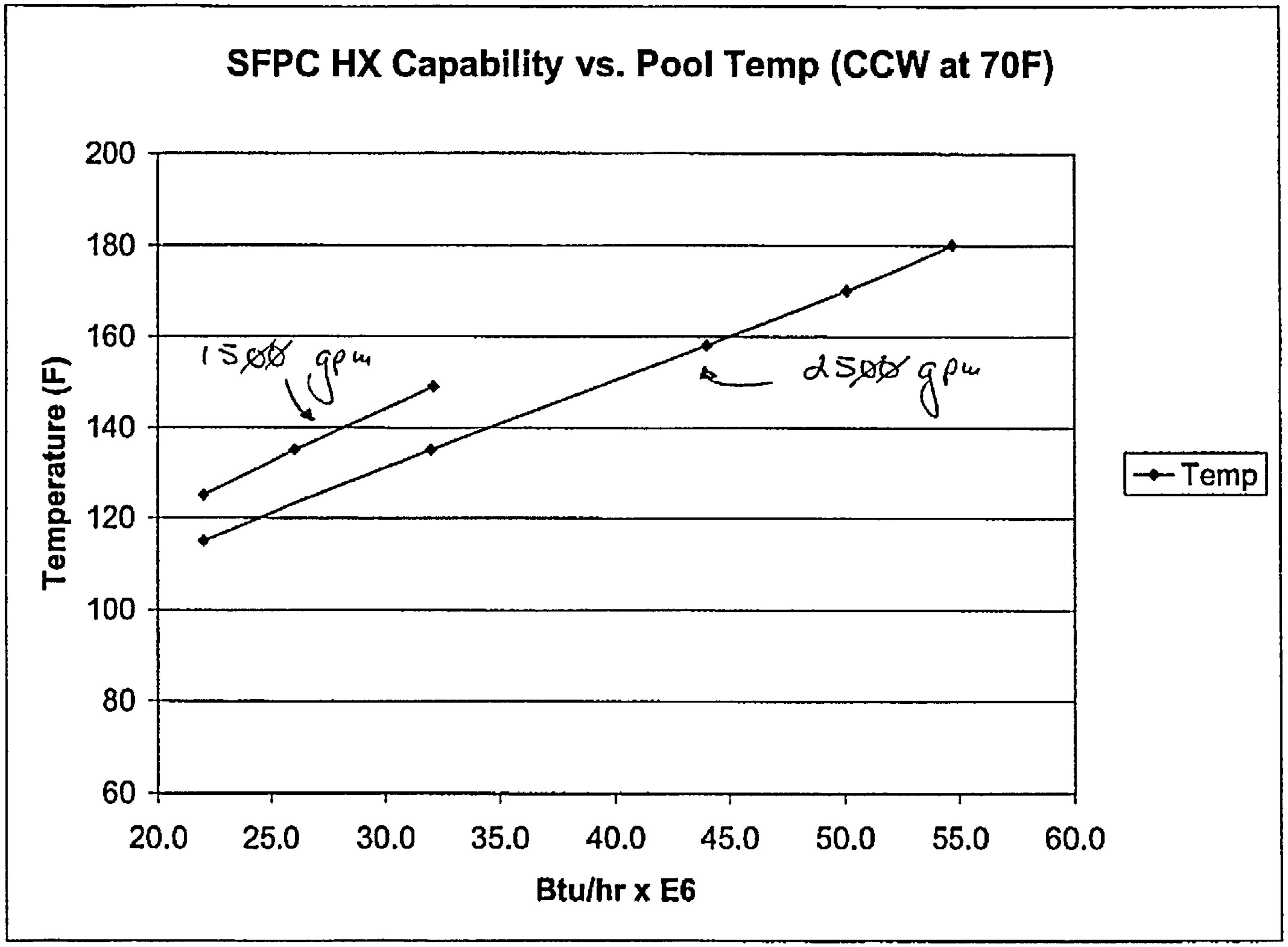
HTC-STX *** Summary ***	Version 3.6		Time: 2.19 58 PM		Date 6/12/2002	File. sfphx-71ccw6%-149 English units	
Item No							
Service	SFPHX-71CCinlet						
Calculation Mode	Rating Case						
Size	34 x 146	Type	BEU - HORZ	Connections	1 Series		1 Parallel
Surface/Unit	2,179		Shells/unit	1		Surf/Shell	2,179 24
Cost/Unit	41,206		Cost/Surf	18 91		Weight/Shell	9,236
Heat Duty	29,943,250		MTD	44.18		F-corr	0 9363
Rate-Service	311.02		Calculated	306.52		Calc Fouling	0.00111

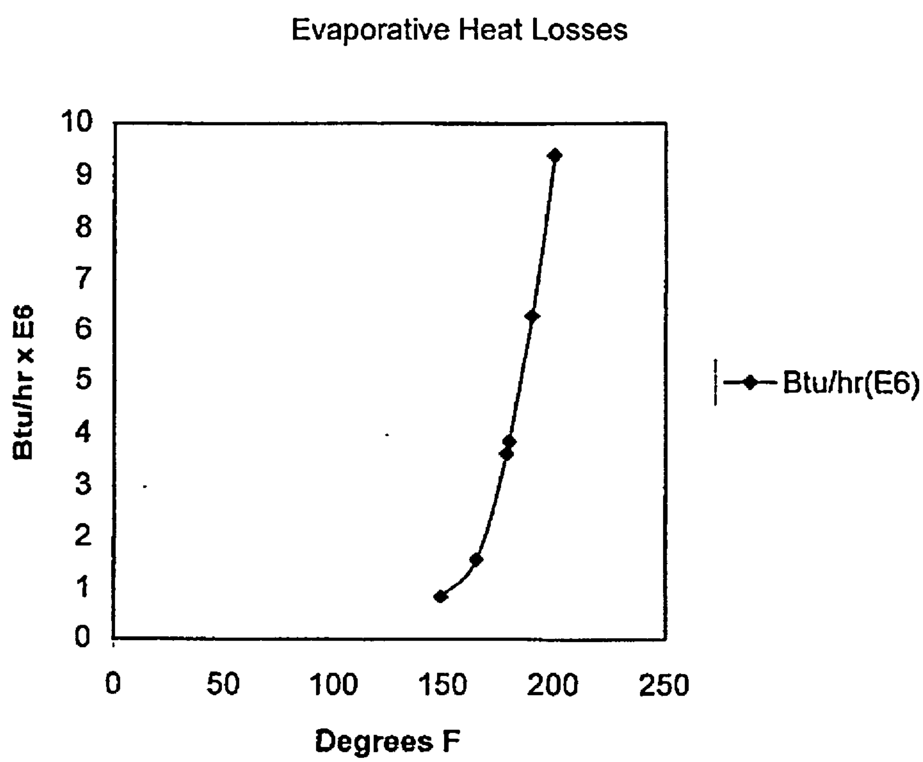
	Shell	Tubes		
			Tubes	0 750 x 0 049 on 0 9375 30 deg
Flow Rate	1501800	736633	Tube No	866 Type PLAIN
Temperature In	71 0	149 0	Baffles·	VERT DBL-SEG 16 5 space 22 0 cut
Temperature Out	90.9	108 7		
Pressure Drop	10 427	1 738	Surface Area	OK. Over design by -1.45%
Velocity	4.196	3 362	Shell pressure Drop	** Allowable exceeded
Passes	1	2	Tube Pressure Drop	OK Within allowable
Film Coef	1979 5	1043 9	Vibration	** Tube vibration likely
Nozzle In	1 x 10 0	10 0	Shell Nozzles	** Rho-V-Sqr exceeds 4000
Nozzle Out	1 x 10 0	10 0	Chan Nozzles	OK. Rho-V-Sqr within 6000

S-C-SF-MEE-1679 REV.0

Btu/hr E6	Temp
22 0	125
26.1	135
32.1	149
22.0	115
32.0	135
44.0	158
50.1	170
54.7	180



Temp	Btu/hr(E6)
149	0 86
165	1.579
179	3.64
180	3.87
190	6.3
200	9.41



DOCUMENTED TELEPHONE CONVERSATION

Reference 5.2

Date: 5/2/02

From: Glen Schwartz, PSEG Fuels

To: Ted DelGaizo, MLEA Inc.

Subject: Future Refueling Plans

1. Based on current projections, Salem Station will replace 76 spent fuel assemblies during upcoming refueling outages. Consequently, at the end of each cycle, the core would contain the following types of assemblies:

    76 assemblies with 1 operating cycle
    76 assemblies with 2 operating cycles
    41 assemblies with 3 operating cycles

    193 total assemblies

DOCUMENTED TELEPHONE CONVERSATION

Reference 5.4

Date: 5/3/02

From: Glenn Schwartz, PSEG Fuels

To: Ted DelGaizo, MLEA Inc.

Subject: Spent Fuel Pool Information

1. There are currently 920 fuel assemblies in the Unit 1 pool as of 1R14 (April 2001) and 812 elements in the Unit 2 pool as of 2R12 (April 2002).

2. Refueling was performed during the recent past Salem outages as shown below:

	Off-Load Started	Off-Load Complete	Re-Load Started
1R13	9/28/99 at 1855	10/1/99 at 0607	10/8/99 at 0411
1R14	4/14/01 at 1508	4/16/01 at 2044	4/26/01 at 1811
2R10	4/14/99 at 0527	4/16/99 at 1549	4/28/99 at 1930
2R11	10/16/00 at 0104	10/18/00 at 0616	10/24/00 at 0807

DOCUMENTED TELEPHONE CONVERSATION

Reference 5.8

Date: 5/6/02

From: Kevin King, PSEG Engineering

To: Ted DelGaizo, MLEA Inc.

Subject: CCW Temperatures with Shutdown Conditions

Question: Based upon shutdown conditions with Service Water inlet temperature at 66°F and approximately 4×10^7 Btu/hr of heat duty, what is the CCW outlet temperature according to the ProtoFlo model of the CCW system.

Answer: With on SW/CCW heat exchanger in operation, the CCW outlet temperature is approximately 7°F higher than the inlet SW temperature. If both CCW heat exchangers are operating and sharing the heat duty, the CCW temperature is approximately 3°F higher than SW temperature.

Ted DelGaizo

From: King, Kevin C. [Kevin.King@pseg.com]
Sent: Wednesday, May 15, 2002 5:32 PM
To: Ted DelGaizo (E-mail)
Subject: CC temperature confirmation

Ted

I ran my P-Flo model, and got the following results with 1 and 2 SFHXs. For both cases, SW temp = 66°F, SW flow = 10000 gpm, CC flow to SFHX = 3000 gpm.

1 SFHX (Q = 44 MBtu/hr):
SFP flow = 2500 gpm
SFP temp = 161.8°F
CC temp = 69.3°F

2 SFHXs (Q = 22 MBtu/hr per hx):
SFP flow = 1740 gpm
SFP temp = 121.0°F
CC temp = 67.7°F

Thus your assumption for 70°F CC temp is valid (and slightly conservative).

Kevin

S-C-SF-MEE-1679 REV. 0
Attachment E
Page E4

CC Temperature Assumption Validation

Preparer:	Kevin King	Date:	5/16/02
Reviewer:	Ted Delgaizo	Date:	5/16/02

1.0 PURPOSE:

To determine the CC inlet temperature to the SFHX (CC supply temperature) based on the SFP heat load and SW temperature requirements specified in Section 2.

2.0 INPUTS/ASSUMPTIONS:

2.1 SW temperature = 66°F [= 63° (Reedy Island historical data) + 3° (Reedy Island to plant intake) – Calc, Section 3.6]

2.2 SW flow to CCHXs = 10000 gpm (max allowable flow). For the plate CCHX (#12), this is 5000 gpm per each half.

2.3 CC flow to SFHX = 3000 gpm (Calc, Section 3.2.3)

2.4 The tube and shell CCHX (#11) is assumed to be 2% plugged (Reference 3.2, Section 3.3.6). No. tubes = 3400*0.98 = 3332; Surface area = 16954 * 0.98 = 16615 ft^2.

2.5 The SFHX is modeled as a fixed heat load. The required SFHX heat load from Calculation Section 3.6 is 44 MBtu/hr (1 SFHX aligned) and 22 MBtu/hr (2 SFHXs aligned). For the two SFHX condition, it is assumed that the total SFP heat load is split equally between the two SFHXs.

3.0 REFERENCES:

3.1 S-1-CC-MDC-1788, Rev. 0, Component Cooling System Thermal-Hydraulic Model (Unit 1)

3.2 S-1-CC-MDC-1817, Rev. 2, Component Cooling System Thermal-Hydraulic Analysis – Unit 1

3.3 S-C-CC-MDC-1798, Rev. 2, Component Cooling System Heat Exchangers

3.4 Procedure S1.OP-SO.RHR-0001, Rev. 14, Initiating RHR

CC Temperature Assumption Validation

Preparer: Kevin King Date: 5/16/02

Reviewer: Ted Delgaizo Date: 5/16/02

4.0 METHODOLOGY:

The Unit 1 CC Thermal-Hydraulic Model developed per Reference 3.1 will be used for this analysis. The default model database "S1CCR0.dbd" from Reference 3.1 will be the baseline database. A new working database "S1CCR0 - Refueling.pdb" will be created for this analysis, and will be saved as default database "S1CCR0 - Refueling.dbd".

Approach:

1. Set the CC model alignment to match actual field conditions.
2. Input the known parameters from Section 2.0 into the model.
3. Run model, and determine the CC System supply temperature (SFHX inlet)*.

***12 CCHX modeling:**

The 12 CCHX is a plate type heat exchanger. It is modeled in Proto-Flo as a UA-counter flow type heat exchanger since the current version of Proto-Flo cannot plate type heat exchangers. That is, a fixed U value is inputted into the model. This requires a trial and error solution within Step 3 above to determine U, using the plate CCHX model developed per Reference 3.3, as follows:

1. Perform an initial run of the system model to determine the CC flows to each half of the plate CCHX.
2. Input the CC flows determined from above, SW flow (5000 gpm per half), SW inlet temperature (66°F) and an initial estimate of the CC inlet temperature into the plate CCHX model.
3. Run the plate CCHX model to determine the U values.
4. Input the U values into the system model.
5. Run system model.
6. Repeat until U values and CC inlet temperatures agree.

CC Temperature Assumption Validation

Preparer:	Kevin King	Date:	5/16/02
Reviewer:	Ted Delgaizo	Date:	5/16/02

5.0 ANALYSIS:

Discussion

This analysis will use the CC System Thermal-Hydraulic Model, which will perform a thermal balance between the CCHXs and the SFHX. The CC system temperatures are determined by Proto-Flo as a result of this thermal balancing. By setting the SW flow to the CCHXs to the maximum value of 10000 gpm, the resultant CC supply temperature (CCHX CC outlet temperature) represents the minimum temperature for a given heat load and SW temperature. Thus if the CC supply temperature is set in the field at a value less than this, the setpoint value could not be maintained as the flow controls would limit SW flow to 10000 gpm.

System Alignment

The Normal Operations alignment from the default model database "S1ccr0.dbd", which has two pumps aligned to the entire system, except the RHRHXs, is modified as follows:

1. The BAE Package is isolated by closing valve 1CC48. This is in accordance with Reference 3.4, which isolates the BAE Package prior to initiating RHR.
2. Letdown HX (LDHX) temperature control valve 1CC71 is closed, as letdown is isolated during shutdown modes.
3. The containment isolation valves are closed, as the containment loads are isolated during shutdown modes. This includes: 1CC113 & 1CC215 (Excess LDHX); 1CC117, 1CC118, 1CC131, 1CC136, 1CC187 & 1CC190 (RCPs)
4. The RHRHX isolation valves (11&12 CC16) remain closed as RHR is not required after a full core offload.
5. Flow to the SFHX is set to 3000 gpm by establishing throttle valve 1CC37 as the flow balancing parameter.
6. With the above valve alignments, only one CC pump is required – 13 CC Pump is selected. Since flow to the SFHX is being set to a specific value, the pump curve to be used is not critical – the "benchmark" curve is selected.
7. All heat exchanger heat loads are set to 0, except the CCHXs and SFHX. The parameters for these HXs (flows, temperatures, 12 CCHX Us) are inputted.

CC Temperature Assumption Validation

Preparer: Kevin King Date: 5/16/02

Reviewer: Ted Delgaizo Date: 5/16/02

Results

Cases were run with both one and two SFHXs and with both one and two CCHXs. Since Unit 1 has one tube and shell CCHX and one plate type CCHX, separate cases were run with each individual CCHX. A summary of the pertinent results are included below. The complete Proto-Flo reports are saved as report files, and are included on the disk included with this evaluation. The 12 CCHX spreadsheet model results are included on pages 5 and 6 of this attachment.

Case	CCHXs	# SFHXs	Q_{SFHX} (MBtu/hr)	CC supply temperature (°F)
1	11 & 12	1	44	69.3
2	11	1	44	75.0
3	12	1	44	74.5
4	11 & 12	2	22	67.7
5	11	2	22	70.7
6	12	2	22	70.6

6.0 CONCLUSION:

The minimum CC supply temperature with a SFP heat load of 44 MBtu/hr and a SW temperature of 66°F is as follows:

# CCHXs	# SFHXs	CC supply temperature (°F)
2	1	69.3
1	1	75.0
2	2	67.7
1	2	70.7

EXCEL Spreadsheet for 12 CCHX Evaluation - EOL Full Core SFP Discharge

	11 & 12 CCHXs; 1 SFHX					11 & 12 CCHXs; 2 SFHXs				
	A half		B half		Total	A half		B half		Total
	SW	CC	SW	CC		SW	CC	SW	CC	
Inlet temp (°F)	66 00	91.37	66.00	91.37		66.00	78.80	66.00	78.80	
Outlet temp (°F)	70 61	69.44	70.64	69.47		68.32	67.82	68.33	67.84	
Mass Flow (lb_m/hr)	2,521,178	530,990	2,521,178	535,008		2,521,178	533,600	2,521,178	537,124	
Volumetric Flow (gpm)	5000	1057	5000	1065		5000	1060	5000	1067	
Fouling (hr-ft^2-°F/Btu)	0.001000		0.001000			0.001000		0.001000		
Properties:										
Tavg (°F)	68.31	80.40	68.32	80.42		67.16	73.31	67.17	73.32	
Density @ Ti (lb_m/ft^3)	62.86	62.63	62.86	62.63		62.86	62.76	62.86	62.76	
Density @ Tav (lb_m/ft^3)	62.84	62.21	62.84	62.21		62.85	62.27	62.85	62.27	
Cp (Btu/lb_m-°F)	1.0008	0.9998	1.0008	0.9998		1.0006	1.0003	1.0006	1.0003	
k (Btu/hr-ft-°F)	0.3483	0.3547	0.3484	0.3547		0.3478	0.3515	0.3478	0.3515	
Dynamic visc (lb_m/ft-hr)	2.473	2.064	2.473	2.064		2.512	2.260	2.512	2.259	
Kinematic visc (ft^2/s)	1.093E-05	9.217E-06	1.093E-05	9.215E-06		1.110E-05	1.008E-05	1.110E-05	1.008E-05	
Pr	7.106	5.820	7.105	5.818		7.227	6 431	7.227	6.430	
Film Resistance:										
Velocity (ft/s)	1.631	0.345	1.631	0.347		1.631	0 346	1.631	0.348	
Re	4476	1122	4477	1131		4408	1029	4408	1036	
Nu	128.22	40.35	128.23	40.59		127.56	39.26	127.56	39.46	
h (Btu/hr-ft^2-°F)	1488.9	477.0	1489.0	479.9		1478 8	460.0	1478.9	462.4	
C (Btu/hr-°F)	2,523,314	530,907	2,523,320	534,924		2,522,809	533,771	2,522,812	537,296	
C_{min} (Btu/hr-°F)	530,907		534,924			533,771		537,296		
C_{max} (Btu/hr-°F)	2,523,314		2,523,320			2,522,809		2,522,812		
r (C_{min}/C_{max})	0.2104		0.2120			0.2116		0.2130		
R (hr-ft^2-°F/Btu)	0.0039719		0.0039594			0.0040542		0.0040430		
U (Btu/hr-ft^2-°F)	251.8		252.6			246.7		247.3		
NTU	2.2767		2.2668			2.2186		2.2101		
Effectiveness	0 8645		0.8631			0.8576		0.8564		
LMTD (°F)	9.63		9.66			4.95		4.96		
Q (MBtu/hr)	11.64		11.71		23.36	5.86		5.89		11.75

EXCEL Spreadsheet for 12 CCHX Evaluation - EOL Full Core SFP Discharge

	12 CCHX only; 1 SFHX				
	A half		B half		Total
	SW	CC	SW	CC	
Inlet temp (°F)	66.00	96.91	66.00	96.91	
Outlet temp (°F)	74.73	74.60	74.76	74.66	
Mass Flow (lb_m/hr)	2,521,178	988,110	2,521,178	994,132	
Volumetric Flow (gpm)	5000	1969	5000	1981	
Fouling (hr-ft^2-°F/Btu)	0.001000		0.001000		
Properties:					
Tavg (°F)	70.36	85.76	70.38	85.78	
Density @ Ti (lb_m/ft^3)	62.86	62.56	62.86	62.56	
Density @ Tav (lb_m/ft^3)	62.83	62.16	62.83	62.16	
Cp (Btu/lb_m-°F)	1.0012	0.9995	1.0012	0.9995	
k (Btu/hr-ft-°F)	0.3493	0.3570	0.3493	0.3570	
Dynamic visc (lb_m/ft-hr)	2.406	1.934	2.406	1.934	
Kinematic visc (ft^2/s)	1.064E-05	8.644E-06	1.064E-05	8.642E-06	
Pr	6.896	5.416	6.895	5.414	
Film Resistance:					
Velocity (ft/s)	1.631	0.642	1.631	0.646	
Re	4600	2229	4601	2244	
Nu	129.41	66.87	129.42	67.20	
h (Btu/hr-ft^2-°F)	1506.9	795.8	1507.1	799.6	
C (Btu/hr-°F)	2,524,232	987,660	2,524,239	993,678	
C_{min} (Btu/hr-°F)	987,660		993,678		
C_{max} (Btu/hr-°F)	2,524,232		2,524,239		
r (C_{min}/C_{max})	0.3913		0.3937		
R (hr-ft^2-°F/Btu)	0.0031243		0.0031181		
U (Btu/hr-ft^2-°F)	320.1		320.7		
NTU	1.5559		1.5495		
Effectiveness	0.7217		0.7200		
LMTD (°F)	14.34		14.36		
Q (MBtu/hr)	22.03		22.11		44.14

	12 CCHX only; 2 SFHXs				
	A half		B half		Total
	SW	CC	SW	CC	
Inlet temp (°F)	66.00	82.02	66.00	82.02	
Outlet temp (°F)	70.49	70.60	70.50	70.62	
Mass Flow (lb_m/hr)	2,521,178	991,204	2,521,178	997,242	
Volumetric Flow (gpm)	5000	1970	5000	1982	
Fouling (hr-ft^2-°F/Btu)	0.001000		0.001000		
Properties:					
Tavg (°F)	68.24	76.31	68.25	76.32	
Density @ Ti (lb_m/ft^3)	62.86	62.73	62.86	62.73	
Density @ Tav (lb_m/ft^3)	62.85	62.25	62.85	62.25	
Cp (Btu/lb_m-°F)	1.0008	1.0001	1.0008	1.0001	
k (Btu/hr-ft-°F)	0.3483	0.3528	0.3483	0.3529	
Dynamic visc (lb_m/ft-hr)	2.475	2.174	2.475	2.173	
Kinematic visc (ft^2/s)	1.094E-05	9.700E-06	1.094E-05	9.698E-06	
Pr	7.113	6.161	7.112	6.160	
Film Resistance:					
Velocity (ft/s)	1.631	0.643	1.631	0.647	
Re	4472	1988	4473	2000	
Nu	128.19	64.40	128.19	64.71	
h (Btu/hr-ft^2-°F)	1488.3	757.4	1488.4	761.1	
C (Btu/hr-°F)	2,523,286	991,311	2,523,290	997,348	
C_{min} (Btu/hr-°F)	991,311		997,348		
C_{max} (Btu/hr-°F)	2,523,286		2,523,290		
r (C_{min}/C_{max})	0.3929		0.3953		
R (hr-ft^2-°F/Btu)	0.0031961		0.0031898		
U (Btu/hr-ft^2-°F)	312.9		313.5		
NTU	1.5153		1.5091		
Effectiveness	0.7131		0.7114		
LMTD (°F)	7.54		7.55		
Q (MBtu/hr)	11.33		11.37		22.69

FORM NC.DE-AP.ZZ-0010-1
CERTIFICATION FOR DESIGN VERIFICATION

Reference No. S-C-SF-MEE-1679, Rev.0
"SFP Cooling System Capability With Core Offload Starting 100-hours After Shutdown"

SUMMARY STATEMENT

Refueling operations are currently restricted to fuel movement no sooner than 168 hours after subcriticality. This is primarily based on evaluation of cooling capability provided by spent fuel pool cooling (SFPC). Decay heat from a full core off-load combined with existing background heat in the spent fuel pool can be removed without exceeding design basis temperature limits provided in vessel decay has occurred for 168 hours. Additional heat removal is required by SFPC if in-vessel decay is reduced and the core is off-loaded sooner. The capability of SFPC to removal increased decay heat from a full core off-load 100 hours after shutdown has been reviewed in this evaluation.

Additional SFPC margin for 100-hour fuel movement is available using lower component cooling water (CCW) supplied to SFPC and total background heat in the pool is less than 6.8E6 Btu/hr. Lower CCW temperature is achieved provided Delaware River temperature is maintained at or below 63°F. Maximum background heat resulting is restricted to that produced from stored spent fuel accumulated through year 2010. This results in the bounding heat load for this evaluation. Maximum pool temperature will increase above UFSAR described temperature of 149°F if a single SFP heat exchanger is dedicated to the refueling unit. Tandem operation using the non-outage unit's SFPC is required to maintain limits for normal operation. Pool temperatures under postulated accident conditions (i.e. loss of a single heat exchanger and SBO) are calculated to be within current design basis.

In addition to increasing SFP temperature, 100 hour core movement will exacerbate humidity/condensation issues that result from surface evaporation as pool temperature increase above 135 °F. This can be mitigated by maintaining reduced pool temperatures using tandem operation with reduced swap-over times.

The methodology for this evaluation is based on benchmarking the SFPC heat exchanger using TEMA design criteria and iterating heat duty, shell (CCW) or tube (SFP) temperatures. Adequate conservatism is used in the evaluation and results are consistent with previous reviews of SFPC performance.

The undersigned hereby certifies (in the right column) that the design verification for the subject document has been completed, the questions from the generic checklist have been reviewed and addressed as appropriate, and all comments have been adequately incorporated.

Design Verifier Assigned by G. Morrison (Signature of Manager/Supervisor)*	10/13/02 John Wiedemann (MLEA,Inc.) /date (Signature of Design Verifier)
Design Verifier Assigned By (signature of Manager/Supervisor)*	Signature of Design Verifier / Date
Design Verifier Assigned By (signature of Manager/Supervisor)*	Signature of Design Verifier / Date
Design Verifier Assigned By (signature of Manager/Supervisor)*	Signature of Design Verifier / Date

*If the Manager/Supervisor acts as the Design Verifier, the signature of the next higher level of technical management is required.

FORM-2
COMMENT / RESOLUTION FORM
FOR DESIGN DOCUMENT
REVIEW/CHECKING OR DESIGN VERIFICATION

REFERENCE DOCUMENT NO. /REV.

CALC NO: S-C-SF-MEE-1679/Rev 0

	COMMENTS	RESOLUTION	
1.	GENERAL: Section 3.0 - Questions resolved by this MEE include: 1. Determination when is it acceptable to perform a full core off-load if fuel movement begins 100 hours after shutdown (based on differential between Delaware River and CCW temperature). 2. Determined maximum SFP inventory (i e last acceptable refueling) that can accommodate a full core off-load at t=100 hrs. 3. Determination of when parallel SFP heat exchanger operation is required. .	. Section 3.0 already implies the time period limits of October 1 to May 15 in question 1. However, the questions in this section were revised to include the aspect of time limits based upon background heat in the pool (e.g. through 2010) and when parallel heat exchangers are needed.	jw
2.	MEE is based on max. decay heat added to SFP cooling at time = 146 hrs. Credit is taken for 46 hrs of decay time to determine maximum heat added to pool from completely off loaded core. Is the heat added from a hotter, partial core offload less than total core at 146 hrs?	A 1/3 core offload, if it could be instantaneously discharged to the SFP at time 100-hours (with no further delay) would have a heat value slightly less than half the heat produced by a full core offloaded at 146 hours. Consequently, the peak heat will always be associated with the full core offload.	jw
3.	Typo last line p. 6 : "77"	Corrected	jw
4.	~~If parallel SFP heat exchanger operation is required prior to fuel movement and hot pool is maintain at 115°F, can parallel operation maintain both pools below a temperature that evaporative cooling does not occur and moisture/humidity issues are eliminated?~~	~~An additional table is added to page 10 to show the HX cycle needed to keep both pools below 135F.~~ Discussion of 135 removed as not germane.	jw
	J. Wiedemann 5/13/02 SUBMITTED BY DATE	T. DelGaizo 5/13/02 RESOLVED BY DATE	Acceptance of Resolution

FORM-1
REGULATORY CHANGE PROCESS DETERMINATION

Document ID	S-C-SF-MEE-1679	Revision 0
Title	SFP Cooling with Core Offload Starting 100-hours After Shutdown	

Activity Description:
The activity determines that during the months from October through May through the year 2010, a fully radiated 193 element core can be off-loaded to either Salem Spent Fuel Pool with a 100-hour In-vessel decay, rather than a 168 hour decay, because the SFPC system is capable of (1) maintaining both Salem pools below 149°F with two SFPC heat exchangers available and (2) maintaining both pools below 180°F with only one heat exchanger available. While this capability meets the requirements of UFSAR Chapter 9.1.3.1, a Technical Specification change will be required because a 168-hour delay is currently required regardless of the time of year or cooling water temperatures.

Note that more than one process may apply. If unsure of any answer, contact the cognizant department for guidance.

1. Does the proposed activity involve a change to the Technical Specifications or the Operating License?	☐ No ☒ Yes	If Yes, contact Licensing; process in accordance with NC.NA-AP.ZZ-0035(Q)
2. Does the proposed activity involve a change to the Quality Assurance Plan? <u>Examples</u>: • Changes to Chapter 17.2 of UFSAR	☒ No ☐ Yes	If Yes, contact Quality Assessment; process in accordance with ND.QN-AP.ZZ-0003(Q)
3. Does the proposed activity involve a change to the Security Plan? <u>Examples</u>: • Change program in NC.NA-AP.ZZ-0033(Q) • Change indoor/outdoor security lighting • Placement of component or structure (permanent or temporary) within 20 feet of perimeter fence • Obstruct field of view from any manned post • Interfere with security monitoring device capability • Change access to any protected or vital area • Modify safeguards systems or equipment	☒ No ☐ Yes	If Yes, contact Security Department; process in accordance with NC.NA-AP.ZZ-0033(Q)
4. Does the proposed activity involve a change to the Emergency Plan? <u>Examples</u>: • Change ODCM • Change liquid or gaseous effluent release path • Affect radiation monitoring instrumentation used in classifying accident severity • Affect emergency facilities, including control rm • Affect communications, telephone, SPDS or Met tower	☒ No ☐ Yes	If Yes, contact Emergency Preparedness
5. Does the proposed activity involve a change to the ISI Program Plan? <u>Examples</u>: • Affect Nuclear Class 1, 2, or 3 Piping, Vessels, or Supports (Guidance in NC.DE-AP.ZZ-0007(Q) Form-11)	☒ No ☐ Yes	If Yes, contact Reliability Programs ISI/IST; process in accordance with NC.NA-AP.ZZ-0027(Q)

FORM-1
REGULATORY CHANGE PROCESS DETERMINATION

Document ID	S-C-SF-MEE-1679	Revision 0
Title	SFP Cooling with Core Offload Starting 100-hours After Shutdown	

6. Does the proposed activity involve a change to the IST Program Plan? <u>Examples</u>: • Affect the design or operating parameters of a Nuclear Class 1, 2, or 3 Pump or Valve (Guidance in NC.DE-AP.ZZ-0007(Q) Form-15)	☒ No ☐ Yes	If Yes, contact Reliability Programs ISI/IST; process in accordance with NC.NA-AP.ZZ-0070(Q)
7. Does the proposed activity involve a change to the Fire Protection Program? <u>Examples</u>: • Change program in NC.DE-PS.ZZ-0001(Q) • Change combustible loading of safety related space • Change or affect fire detection system • Change or affect fire suppression system/component • Change fire door, damper, penetration seal or barrier • See NC.DE-AP.ZZ-0007, Forms 3, 4 and 14 for details	☒ No ☐ Yes	If Yes, contact Design Engineering; process in accordance with NC.DE-PS.ZZ-0001(Q)
8. Does the proposed activity involve Maintenance, which restores SSCs to their design condition? Examples: • CM or PM activity • Design and configuration remain unchanged • Implements an approved Design Change?	☒ No ☐ Yes	If Yes, contact Maintenance; process in accordance with NC.WM-AP.ZZ-0001(Q)
9. Is the proposed activity a temporary change (T-Mod) which ***meets all the following conditions***? • Directly supports maintenance and is NOT a compensatory measure to ensure SSC operability. • Will be in effect during power operation for **less than 90 days.** • Activity will NOT change the normal system lineup. • SSCs will NOT be operated in a manner that could impact the function or operability of a safety related or Important-to-Safety system.	☒ No ☐ Yes	If Yes, contact Engineering; process in accordance with NC.NA-AP.ZZ-0013(Q)
10. Does the proposed activity consist of changes to maintenance procedures which do NOT affect SSC design, performance, operation or control? **Note:** Procedures containing important information concerning SSC design, performance, operation or control, including those for Tech Spec required surveillance and inspection, ***require 50.59 screening***. Examples include acceptance criteria for valve stroke times or other SSC function, torque values, and types of materials (e.g., gaskets, elastomers, lubricants, etc)	☒ No ☐ Yes	If Yes, contact Maintenance; process in accordance with NC.NA-AP.ZZ-0001(Q)

FORM-1
REGULATORY CHANGE PROCESS DETERMINATION

Document ID	**S-C-SF-MEE-1679**	Revision 0
Title	**SFP Cooling with Core Offload Starting 100-hours After Shutdown**	

11. Does the proposed activity involve a *minor* UFSAR change (including documents incorporated by reference)? <u>Examples</u>: • Reformatting, simplification or clarifications that do not change the meaning or substance of information • Removes obsolete or redundant information or excessive detail • Corrects inconsistencies within the UFSAR • Minor correction of drawings (such as mislabeled ID)	☒ No ☐ Yes	If Yes, process in accordance with NC.NA-AP.ZZ-0035(Q)
12. Does the proposed activity involve a change to a Q-listed Administrative Procedure (NAP, SAP or DAP) governing the conduct of station operations? <u>Examples</u>: • Organization changes	☒ No ☐ Yes	If Yes, process in accordance with NC.NA-AP.ZZ-0001(Q) and NC.DM-AP.ZZ-0001(Q)
13. Does the proposed activity involve a change to a regulatory commitment not covered by another regulation-based change process?	☒ No ☐ Yes	If Yes, contact Licensing and process in accordance with NC.NA-AP.ZZ-0030(Q)
14. Does the activity impact other programs controlled by regulations, operating license or Tech Spec? <u>Examples</u>: • Chemical Controls Program • NJ "Right-to-know" regulations • OSHA regulations • NJPDES Permit conditions • State and/or local building, electrical, plumbing, storm water management or "other" codes and standards	☒ No ☐ Yes	If Yes, process in accordance with applicable procedures such as: NC.NA-AP.ZZ-0038(Q) NC.LR-AP.ZZ-0037(Q)
15. Has the activity already received a 10CFR50.59 review or evaluation under another process? <u>Examples</u>: • Calculation • Design Change Package or OWD change • Procedure for a Test or Experiment • DR/Nonconformance • Incorporation of previously approved UFSAR change	☒ No ☐ Yes	Take credit for 10CFR50.59 review or evaluation already performed.

If any other program or regulation *may be* affected by the proposed activity, contact the department indicated for further review in accordance with the governing procedure. If responsible department determines their program is not affected, attach a written explanation.

FORM-1
REGULATORY CHANGE PROCESS DETERMINATION

Document ID	**S-C-SF-MEE-1679**	Revision 0
Title	**SFP Cooling with Core Offload Starting 100-hours After Shutdown**	

If all of the answers on the previous pages are "No," then check A below:

A. ☐ None of the activity is controlled by any of the processes above, therefore a 10CFR50.59 review IS required. Complete a 10CFR50.59 screen.

If one or more of the answers on the previous pages are "Yes," then check either B or C below as appropriate:

B. ☒ All aspects of the activity are controlled by one or more of the processes above, therefore a 10CFR50.59 review **IS NOT** required.

C. ☐ Only part of the activity is controlled by the processes above, therefore a 10CFR50.59 review **IS** required. Complete a 50.59 screen.

	Printed Name	Signature	Date
Preparer:	T. J. DelGaizo	T. J. DelGaizo	5/5/02
Reviewer:	JOHN WIEDEMANN	John Wiedemann	6/13/02

APPENDIX 1

Error Notice Log

Software Number: A-0-ZZZ-MCS-0113 Revision: 00
Software Name: CROSSTIE
Application: ____ Mainframe X Personal Computer

Error Notice Number	Date Received	Source/Description	CR Number	Date Closed / Distributed

APPENDIX 1

Error Notice Disposition Form

Error Identification

Software Number: A-0-ZZ-MCS-0113 Revision: 00

Software Name: CROSSTIE

Application: ______ Mainframe X Personal Computer

Error Notice Number: ____________ Source: ________________

Error Description:

Error Evaluation

Applicable to Platform: ______ Yes ______ No

Preliminary Disposition:

Affected Calculations (list):

DEF Number: ________________ Date: ____________

Close-out Action Items:

Software Sponsor: ______________________ Date: ______

APPENDIX 2

INITIAL BENCHMARK VERIFICATION

ATTACHMENT 1: Holtec document ID HI-931099, "Verification and Validation Documentation for Computer Program CROSSTIE"